Geol Survey

A guide to the geology of the Waterloo-Valmeyer area

David L. Reinertsen

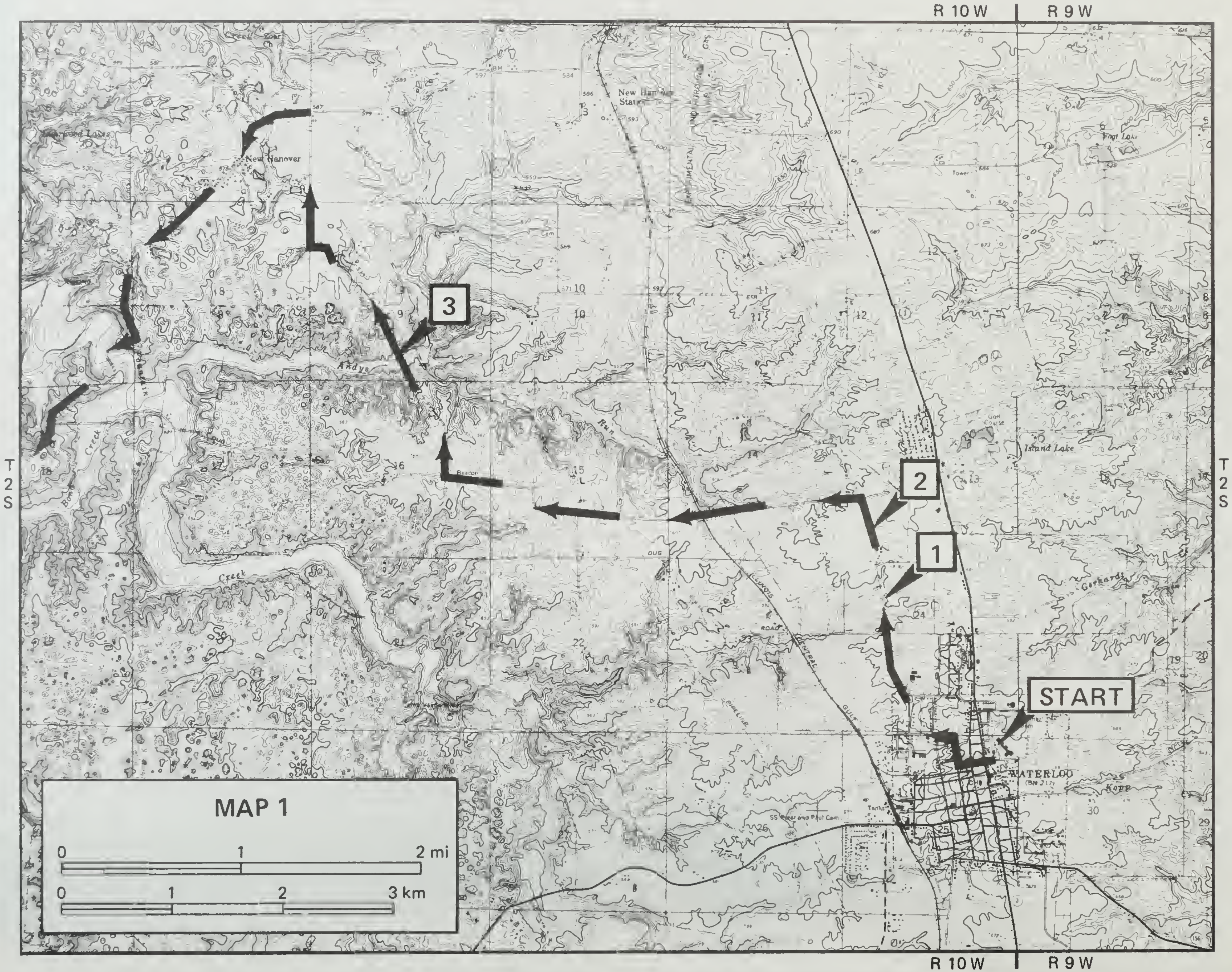
Field Trip 1981 D
October 31, 1981
Department of Energy and Natural Resources
State Geological Survey Division
Champaign, IL 61820

A guide to the geology of the Waterloo-Valmeyer area

David L. Reinertsen

Field Trip 1981 D
October 31, 1981
Illinois State Geological Survey
615 East Peabody Drive
Champaign, IL 61820

Printed by the authority of the State of Illinois/October 1981/400



R 10 W
R 9 W
T 2 S
MAP 1
0
1
2 mi
0
1
2
3 km
START
1
2
3
WATERLOO
New Hanover
Island Lake
Andys
Run
Creek

guide to the route

INTRODUCTION

Waterloo was originally settled in 1779 by a small group of American pioneers who made their way westward in spite of the State of Virginia's prohibition of settlement. At that time, Illinois was a county of that state. This was the first permanent English-speaking settlement to be established north of the Ohio River and was for some years known as Bellefontaine. The spring for which the town was named still flows on the southwestern outskirts of Waterloo.

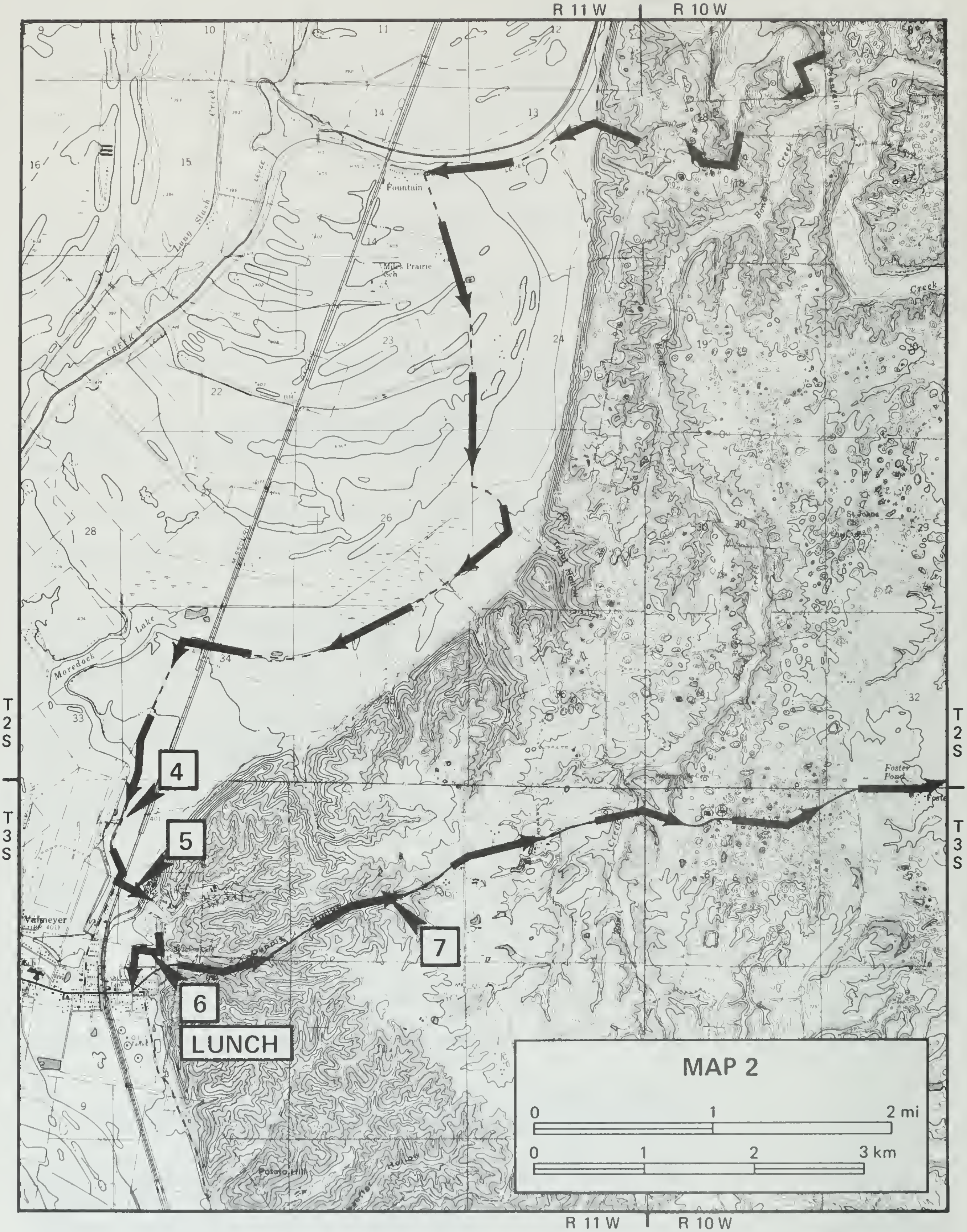
Waterloo is located nearly on the crest of the Waterloo-Dupo Anticline. The highest part of this bedrock structure lies 4 miles to the north; here it is plunging gently southward.

The 7.5-minute topographic quadrangles that were used for this field trip area are: Waterloo, Columbia, Valmeyer, and Renault.

Miles to next point	Miles from start	
		Line up heading south on the west side of Bellefontaine Drive and north of Hecker Street across from Waterloo Junior High School.
0.0	0.0	Head south on Bellefontaine Drive.
0.1	0.1	STOP, 1-way. TURN RIGHT (west) on East First Street.
0.05	0.15	STOP, 2-way; State Route (SR) 3. CONTINUE AHEAD STRAIGHT (west).
0.1	0.25	STOP, 2-way; North Main Street. CONTINUE AHEAD STRAIGHT (west).
0.1	0.35	STOP, 1-way. TURN RIGHT (north) on North Church Street.
0.15	0.5	TURN LEFT (west) on Veteran's Drive.
0.25	0.75	STOP, 2-way. TURN RIGHT (north) on North Moore Street.
0.25	1.0	Gibault Catholic High School on right. Note view to left toward Mississippi River valley.
0.55	1.55	**STOP 1. Park as close to the edge of the road as safety permits. Discussion of Waterloo oil field at oil tank battery on west side of road.**
0.0	1.55	Leave Stop 1. CONTINUE AHEAD (north).

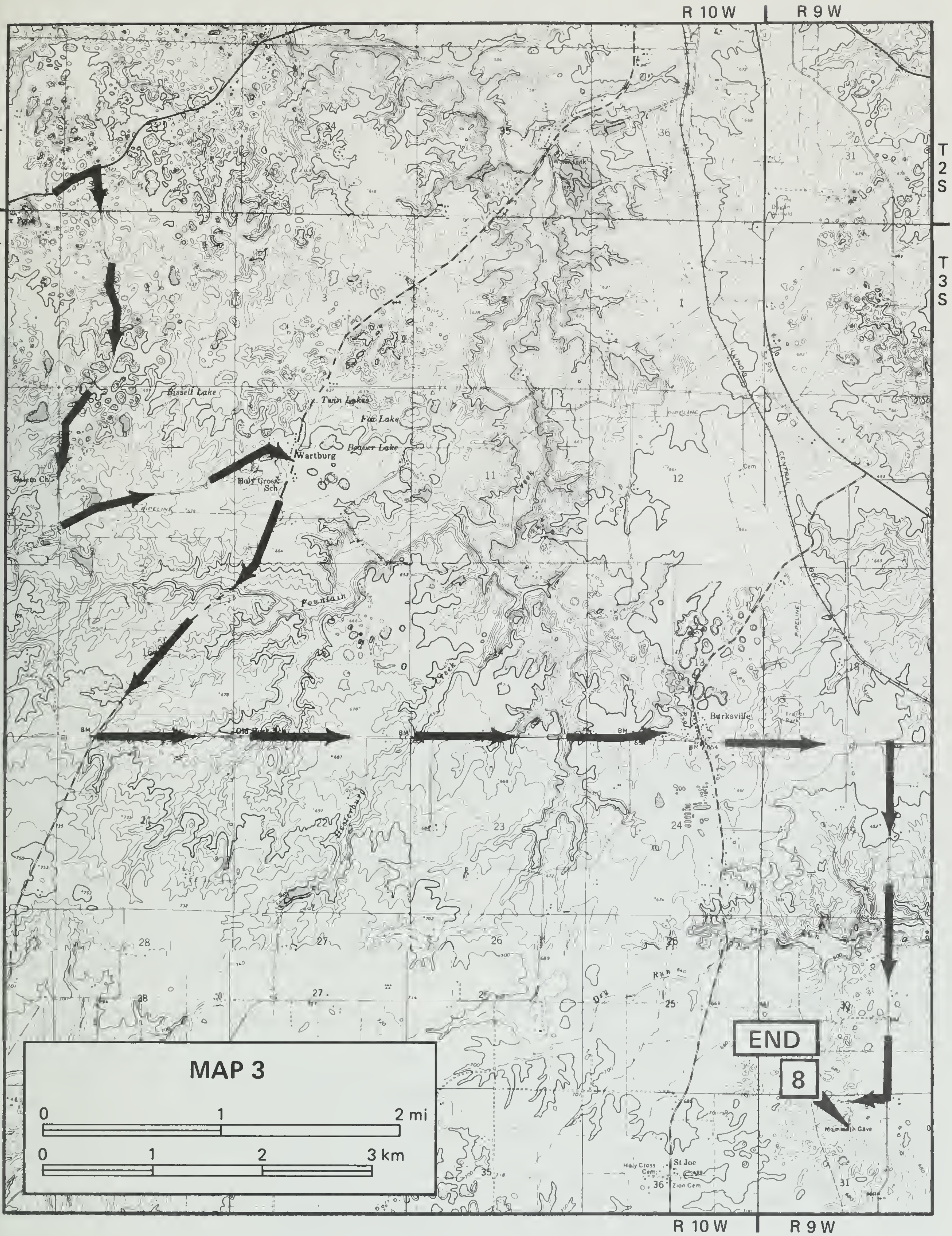
Miles to next point	Miles from start	
0.4	1.95	**STOP 2. Park as close to the edge of the road as safety permits at the crest of the hill. Assemble on west side of the road. Discussion of the land surveys in Illinois and physiography of the field trip area.**
0.0	1.95	Leave Stop 2. CONTINUE AHEAD (north).
0.2	2.15	CAUTION: DANGEROUS INTERSECTION. TURN LEFT (west) on HH Road (1940 N) from Moore Road (1110 E).
0.8	2.95	Stone building to right. A number of churches, homes, and farm buildings in the field trip area are constructed of native stone.
0.05	3.0	CAUTION: Unguarded Illinois Central Gulf (ICG) Railroad crossing. CONTINUE AHEAD (westerly). Area ahead is underlain by bedrock strata of Pennsylvanian age, the youngest bedrock in this field trip area. Note the gently rolling topography here and compare it to topography that will be seen later today.
0.7	3.7	T-road from left. CONTINUE AHEAD (west).
0.25	3.95	TURN RIGHT (north).
0.1	4.05	T-road from left. TURN LEFT (west).
0.4	4.45	Prepare to turn right.
0.1	4.55	TURN RIGHT (north) on Andy Road (880 E).
0.75	5.3	CAUTION; narrow bridge across Andys Run. CONTINUE AHEAD (north) and prepare to stop. Do NOT stop on bridge.
0.05	5.35	**STOP 3. Pleistocene drift exposure in roadcut on right side of road.**
0.0	5.35	Leave Stop 3. CONTINUE AHEAD (northerly).
0.3	5.65	To the left is a large sinkhole.
0.05	5.7	Another large sinkhole to the left in the corn field. This one frequently has a pond in it. To the north are two somewhat smaller sinkholes.
0.4	6.1	BEAR LEFT (west).
0.05	6.15	TURN RIGHT (north).
0.25	6.4	Area to the right (east) doesn't have sinkholes, but the area to the left (west) has a number of large sinkholes. The row of trees in the depression to the left is in a large sinkhole.
0.1	6.5	The pond south of the barn to the left is artificial but was built in an arm of a large sinkhole that extends to the west and north of the farm buildings.

Miles to next point	Miles from start	
0.45	6.95	STOP, 1-way. TURN LEFT (west) on Hanover Road (2150 N).
0.25	7.2	CAUTION, skewed crossroad. TURN LEFT (southwest) on Hanover Road.
0.2	7.4	CAUTION, enter hamlet of Hanover.
0.3	7.7	Leave Hanover. CONTINUE AHEAD (southerly). The route traverses an area that has numerous sinkholes; some are water filled and many contain stands of trees. Some of the water-filled sinkholes are bright green because of abundant algae growing on the water, the result of high nutrient levels from barn lots draining into them.
0.6	8.3	Oak Ridge Subdivision to right. CONTINUE AHEAD STRAIGHT (southerly) and leave the blacktop.
0.65	8.95	CAUTION: narrow bridge across Fountain Creek. Andys Run empties into Fountain Creek about ¼ mile southeast of the bridge. CAUTION: the road ahead up the hill is rough.
0.2	9.15	Vertical exposure of Wisconsinan loess in roadcut to right.
0.4	9.55	T-road from left. CONTINUE AHEAD (southerly and then westerly).
0.3	9.85	Note three sinkholes to left. The middle one contains water but those on either side are dry.
0.15	10.0	T-road from left. CONTINUE AHEAD (northwesterly).
0.25	10.25	Wisconsin loess exposed in roadcut; best exposed on north side of road. Loess is 15 to 20 ft thick. Road is descending the east valley wall of the Mississippi River.
0.05	10.3	The road steepens below the Pleistocene-Mississippian bedrock contact. Mississippian limestone exposed along both sides of the road.
0.4	10.7	STOP, 1-way. Intersection of HH Road (1970 N) and Bluff Road (570 E) at the bottom of the east valley wall of the Mississippi River. CONTINUE AHEAD (west) on HH Road on top of levee.
0.45	11.15	Recent heavy rains have caused severe slumping to the right along the channelized part of Fountain Creek.
0.55	11.7	Descend the levee and TURN LEFT (south) on Bluff Road (480 E).
1.85	13.55	T-road intersection. BEAR LEFT (southeast) at 1770 N and CONTINUE AHEAD (southerly) on blacktop.
1.25	14.8	The large rock spires exposed to the left (south) appear to be the sides of an old sinkhole that was breeched by lateral cutting of the Mississippi Valley. A number of similar appearing pinnacles that occur to the southwest along the


R 11 W
R 10 W
Fountain
Miles Prairie Sch
Moredock Lake
T 2 S
T 3 S
4
5
6
LUNCH
7
Valmeyer
Foster Pond
St Johns Ch
Potato Hill
MAP 2
0
1
2 mi
0
1
2
3 km
R 11 W
R 10 W

Miles to next point	Miles from start	
		bluff probably have the same origin. This view shows the east limb of the Valmeyer Anticline. Although the dip of the strata is only 1 or 2 degrees, it doesn't take much horizontal distance to bring this unit far up the bluff face to the southwest.
0.5	15.3	To the left at the top of the high bluff is the same pinnacled rock stratum that occurred at floodplain level at mileage 14.8.
0.5	15.8	CAUTION: guarded Missouri Pacific (MoPac) Railroad crossing, 2 tracks. CONTINUE AHEAD (west) and then TURN LEFT (south).
0.35	16.15	View to left at about 11 o'clock shows caverns that have resulted from the underground mining of limestone.
0.85	17.0	**STOP 4. View to southeast and discussion of the Valmeyer Anticline. Park across from the lane to the east and as close as safety permits to the ditch on the right side of the blacktop.**
0.0	17.0	Leave Stop 4. CONTINUE AHEAD (southerly).
0.4	17.4	CAUTION: TURN LEFT (southeast) on Quarry Road and cross UNGUARDED MoPac RR crossing; 2 tracks.
0.1	17.5	TURN RIGHT (south) and park west of the Office of Plant No. 3, Columbia Quarry Company.
		STOP 5. Discussion of the geology and some of the operations of the Valmeyer Quarry.
0.0	17.5	Leave Stop 5. TURN AROUND and retrace route to entrance of parking area. Then TURN RIGHT (east) past the north side of the office building. Use EXTREME CAUTION in this area as railroad cars are being switched and large trucks are being loaded and weighed. Cross several switching tracks. Ahead note the sharp downturn of the strata along the southwest flank of the Valmeyer Anticline.
0.1	17.6	TURN RIGHT (south) just beyond switch track. Do NOT continue ahead through gate.
0.35	17.95	CAUTION: TURN RIGHT (westerly) across narrow concrete bridge.
0.1	18.05	**STOP 6. Lunch in Valmeyer town park.**
0.0	18.05	Leave Stop 6. CONTINUE AHEAD (west).
0.05	18.1	STOP, 2-way. TURN LEFT (south) on 4th Street.
0.1	18.2	STOP, 4-way. CONTINUE AHEAD STRAIGHT (south).
0.1	18.3	STOP, 4-way. CONTINUE AHEAD (south) on 4th Street.
0.05	18.35	STOP, 2-way. TURN HARD LEFT (northeast) SR 156.

Miles to next point	Miles from start	
0.2	18.55	To the right is an exposure of steeply dipping Burlington Limestone.
0.4	18.95	To the left is the Kimmswick Limestone in the roadcut and just ahead to the right.
0.1	19.05	To the right just beyond the bridge the bedrock strata appear to be approximately on the crest of the Valmeyer Anticline.
0.1	19.15	This is a covered area that is underlain by the Maquoketa Shale.
0.05	19.2	A small upfold here has brought the Kimmswick back to the surface in the small roadcut.
0.15	19.35	To the left behind the houses the ascending geologic section shows the following formations: Hannibal Shale, Chouteau Limestone, Fern Glen, and Burlington Limestone.
0.1	19.45	The Fern Glen Formation is exposed on the right side of the road in a large roadcut. It is reddish and greenish gray. Some chert nodules as much as 4 to 5 in. thick are present.
0.35	19.8	To the left, the roadcut shows about 17 ft of Burlington Limestone overlain by some 45 ft of Keokuk Limestone.
0.15	19.95	**STOP 7. Mississippian Valmeyeran strata exposed in roadcut on north side of SR 156.** USE EXTREME CAUTION in parking here as space is small. Do NOT stand on the highway to look at the exposure; traffic CAN BE FAST AND DANGEROUS!!
0.0	19.95	Leave Stop 7. CONTINUE AHEAD (northeasterly).
0.1	20.05	Poor exposure of Pleistocene materials in roadcut.
0.75	20.8	This area is underlain by the St. Louis Limestone and sinkholes are well developed here.
0.6	21.4	Cross Bond Creek. This is one of the few creeks in this area.
0.55	21.95	Notice the two sinks here with different water levels in them. The west one has a much lower level.
1.1	23.05	CAUTION: enter hamlet of Foster Pond.
0.25	23.3	Leave Foster Pond.
0.25	23.55	The highway in this vicinity is quite crooked because it was constructed along the higher ground between the neighboring sinkholes.
0.2	23.75	Prepare to turn right. Note the deep, tree-filled sinkhole to right.
0.15	23.9	TURN RIGHT (south) on F Road (820 E).


R 10 W
R 9 W
T 2 S
T 3 S
Bissell Lake
Twin Lakes
Fox Lake
Beaver Lake
Wartburg
Holy Cross Sch
Salem Ch
PIPELINE
Fountain
Creek
Old State Rd
Burksville
ILLINOIS CENTRAL GULF
Dry Run
END
8
Mammoth Cave
Holy Cross Cem
St Joe
Zion Cem
MAP 3
0
1
2 mi
0
1
2
3 km

Miles to next point	Miles from start	
1.85	25.75	Salem-Baum Church Memorial to right. This burned-out church building was constructed of native limestone.
0.3	26.05	CAUTION: unprotected crossroad. TURN LEFT (east) on 1420 N.
0.45	26.5	View to northeast at 10:30 o'clock shows city of Waterloo on the distant hilltop.
0.75	27.25	CAUTION: enter hamlet of Wartburg.
0.3	27.55	STOP, 1-way. TURN RIGHT (south) on Maeystown Road (940 E).
0.1	27.65	Leave Wartburg.
0.65	28.3	Cross Fountain Creek. Note stone arch bridge at site of old road just to the left of the present road.
1.1	29.4	Prepare to turn left.
0.1	29.5	TURN LEFT (east on blacktop KK Road 91300 N).
0.65	30.15	Cross creek. CONTINUE AHEAD (east).
0.15	30.3	Old Rock School to left at T-road. CONTINUE AHEAD (east).
1.55	31.85	Rough, wavy road just before creek.
0.3	32.15	CAUTION: narrow culvert.
0.45	32.6	CAUTION: narrow culvert.
0.2	32.8	CAUTION: enter hamlet of Burksville.
0.15	32.95	STOP, 2-way. CAUTION, CONTINUE AHEAD (east) across Kaskaskia Road (1160 E) at sign pointing toward Mammoth Cave (of Illinois).
0.25	33.2	This upland area has a number of large water-filled sinkholes in which the water level is close to upland surface.
0.75	33.95	Prepare to turn right.
0.1	34.05	TURN RIGHT (south) on 1270 E. The road to the south is quite rough.
1.0	35.05	This area is pitted with sinkholes.
0.9	35.95	Prepare to turn right.
0.1	36.05	TURN RIGHT (west) at entrance to Mammoth Cave property.
0.1	36.15	Note the water in the sinkhole to the left. This is close to Mammoth Cave.
0.1	36.25	TURN LEFT (south) at old house, just before the gate.
0.1	36.35	**STOP 8. Follow parking directions. Mammoth Cave of Illinois.**

the geologic framework

AN OVERVIEW

The Waterloo-Valmeyer Geological Science Field Trip will acquaint you with some aspects of the general geology, surface topography, and mineral resources of part of Monroe County in southwestern Illinois, about 20 miles south of St. Louis. The area is geologically complex and presents a variety of interesting geologic and physiographic features. The broad, deep, flat-bottomed Mississippi River valley is the most prominent topographic feature. It contrasts sharply with the deeply dissected, undulating upland to the east. Steep, spectacular bluffs cut in massive limestone formations of Mississippian age rise abruptly to heights greater than 200 feet above the valley floor. The upland, where these limestone formations form part of the bedrock surface, exhibits some of the best-developed sinkhole topography in Illinois.

The Waterloo-Valmeyer area is situated at the southwestern edge of the glaciated portion of Illinois. Although Pleistocene glaciers have covered nearly 85 percent of the state at one time or another during the last million years, no deposits definitely identified as pre-Illinoian have been found in the field trip area. If pre-Illinoian glaciers did extend across this part of Illinois, erosion during subsequent glaciations has removed all evidence of them (see attached "Pleistocene Glaciations in Illinois"). Drift of Illinoian age, deposited between about 250 and 200 thousand years ago, thinly mantles much of the upland. Although Wisconsinan glaciers did not reach the Waterloo-Valmeyer area during the last 75,000 years, thick Wisconsinan outwash deposits occur in the Mississippi River valley. In addition, wind-blown Wisconsinan loess thickly blankets the valley bluffs and the nearby upland to form the surficial materials throughout this area. Glacial deposits have an aggregate thickness of 30 to 35 feet in the field trip area.

The glacial deposits are underlain by much older, consolidated sedimentary bedrock formations up to 3,700 feet thick (fig. 1). These bedrock formations consist mainly of sandstone, shale, and limestone that were deposited layer upon layer in the ancient shallow seas that repeatedly invaded the midcontinent region during the Paleozoic Era between 550 and 270 million years ago. The bedrock strata are divided into major subdivisions known as systems, each of which was deposited during a specified period of geologic time. Approximately the uppermost 1,000 feet of these sedimentary rock strata, belonging to the Ordovician, Mississippian, and Pennsylvanian Systems, are exposed (fig. 2). Devonian, Silurian, and Cambrian formations are known from nearby areas where they are exposed and also from deep oil test-wells that penetrate them. The base of the Cambrian strata rests upon an ancient basement of Precambrian igneous and metamorphic rocks that are more than one billion years old. If younger Pennsylvanian formations and later rock strata were deposited across the field trip area, all evidence of them has been removed during millions of years of erosion.

Geologically the Waterloo-Valmeyer area is situated at the southwestern margin of the Illinois Basin, a large bedrock structure containing a thick succession of Paleozoic sedimentary rocks that have been warped into a great spoon-shaped depression, 250 to 300 miles in diameter, that covers most of Illinois and adjacent parts of Indiana and Kentucky (figs. 3 and 4 and attached Geologic Map of Illinois). The deepest part of the Illinois Basin is about 105 miles southeast of here in northeastern Pope County where deep oil-test wells indicate that Paleozoic strata probably exceed 17,000 feet. Regionally the strata in the field trip area are gently tilted down to the east into the basin. Westward they rise onto the Ozark Dome, a broad domal uplift in southeastern Missouri (fig. 4). The older Paleozoic formations and the Precambrian rocks that are buried in the field trip area rise to the bedrock surface on the dome.

The regional tilt of the Paleozoic rocks in the Waterloo-Valmeyer area is interrupted by two major, sharp upfolds or arches of the bedrock called anticlines. The Waterloo-Dupo Anticline crosses the northern part of the area from north-northwest to south-southeast. The Valmeyer Anticline crosses the central-western part of the area from northwest to southeast (fig. 2). The intersections of these anticlines with the Mississippi River bluffs offer the best opportunities in Illinois to examine the effects of crustal warping. These structures have been important sources of stone and oil for many years.

MINERAL PRODUCTION

During 1979, the last year for which complete mineral production records are available, of the 102 counties in Illinois, 98 reported mineral production. The total value of all minerals extracted from Illinois was more than $2.1

SYSTEM	SERIES	GROUP, STAGE	FORMATION, MEMBER	ROCK TYPE	THICK-NESS	DESCRIPTION
QUATER-NARY		Holocene				Sand, silt, clay
	Pleistocene	Wisconsinan	Peoria			Loess
			Roxana			Loess
		Illinoian				Till, some outwash
PENNSYLVANIAN		Kewanee	Carbondale: Hanover Ls, No. 4 Coal, No. 2 Coal		40	Sandstone; siltstone; shale; limestone; coal; underclay
		McCormick			25	Sandstone; siltstone; shale; thin coal
MISSISSIPPIAN	Valmeyeran		Ste. Genevieve		70	Limestone, oolitic, some chert
			St. Louis		245	Limestone, some dolomite, some chert
			Salem		80	Limestone, some oolites, some chert
			Ullin		65	Limestone, some chert
			Warsaw		25	Shale
			Keokuk		60	Limestone, very cherty
			Burlington		100	Limestone very cherty
			Fern Glen		60	Limestone, some chert; shale
	Kinderhookian		Chouteau		30	Limestone and shale
DEVONIAN		New Albany			15	Shale
SILURIAN					75	Dolomite, cherty
ORDOVICIAN	Cincin-natian	Maquoketa			150	Siltstone; shale; some limestone
	Cham.	Kimmswick			100	Limestone
OLDER ORDOVICIAN AND CAMBRIAN STRATA					2450	Limestone; dolomite; sandstone; shale
PRECAMBRIAN						Granite; other igneous and metamorphic rocks

ISGS 1981

Figure 1. Generalized geologic column of strata in the Waterloo-Valmeyer area.

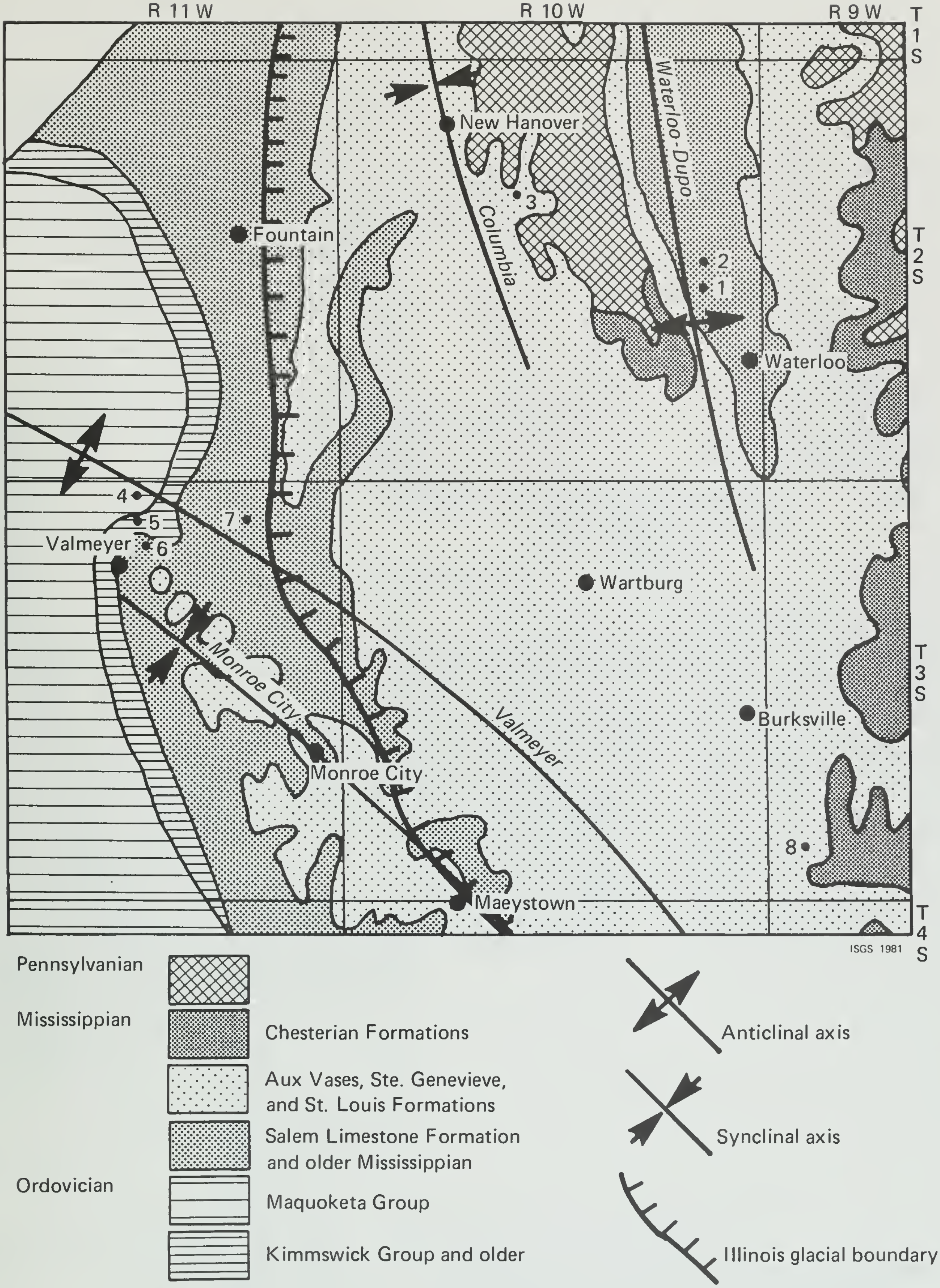


Figure 2. Bedrock geology of Waterloo-Valmeyer area.

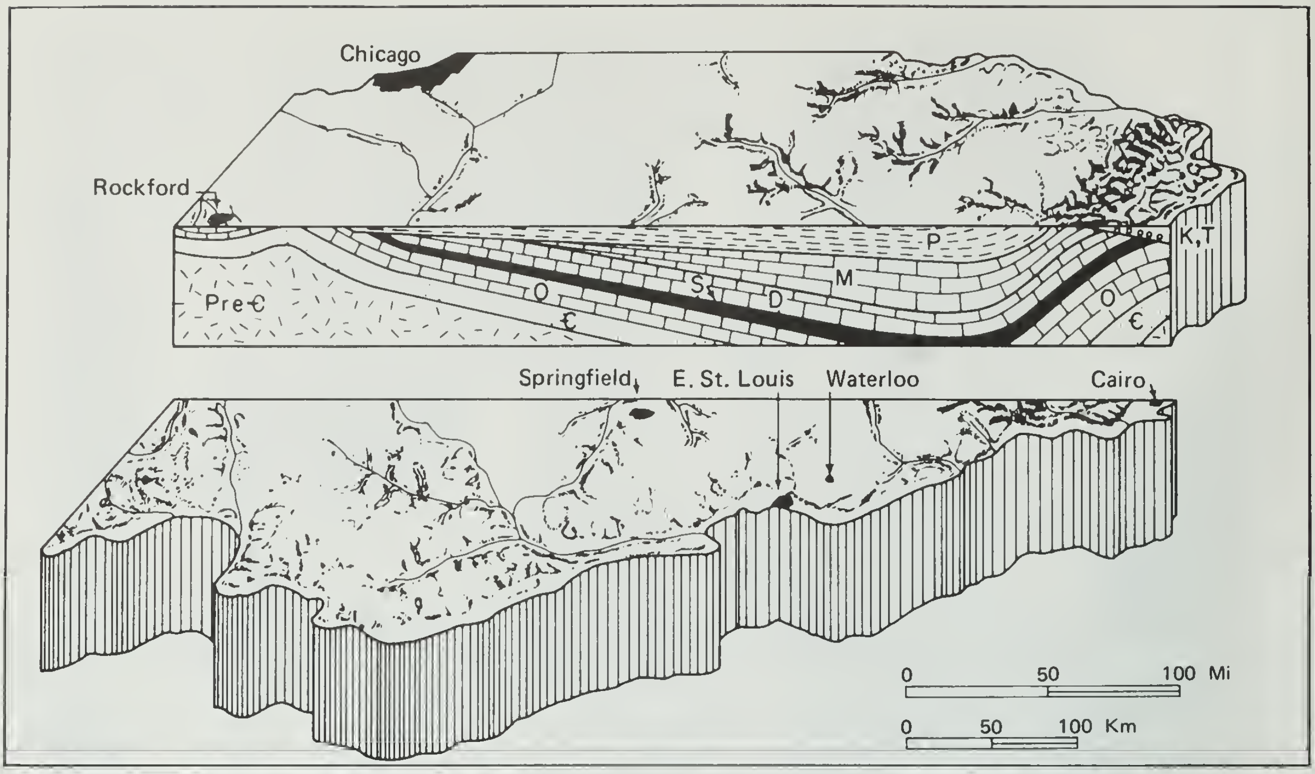


Figure 3. *(above)* Stylized north-south cross section shows the structure of the Illinois Basin. In order to show detail, the thickness of the sedimentary rocks has been greatly exaggerated and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. They form a depression that is filled with layers of sedimentary rocks of various ages: Cambrian (C), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). The scale is approximate.

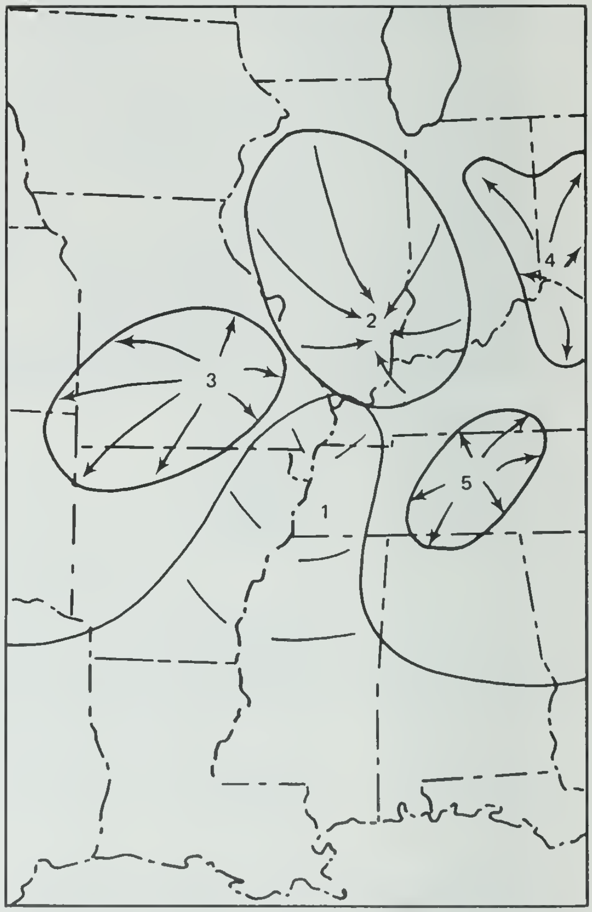


Figure 4. *(right)* Index map showing the location of the Mississippi Embayment and adjacent major structures: (1) Mississippi Embayment, (2) Illinois Basin, (3) Ozark Dome, (4) Cincinnati Arch, and (5) Nashville Dome.

billion. The total value of all minerals extracted, processed, and manufactured in the State was nearly $3.8 billion.

Mineral resources extracted from Monroe County include crude oil, stone, and groundwater. Oil production amounted to 15,000 barrels valued at $349,000. Two quarries produce stone, but production figures and values are withheld to avoid disclosing confidential data of individual companies. Abundant groundwater supplies are readily available from the thick sand and gravel deposits in the Mississippi Valley. The thin glacial deposits on the upland are unfavorable for the construction of drilled wells. The limestones and sandstones of the Mississippian System provide sources of fairly abundant quantities of water. However, because of pollution problems in shallow, cavernous limestones, special treatment must be given to water from wells constructed in this type of aquifer.

1 **Stop 1. Waterloo oil field. SE¼SE¼NW¼NW¼ Sec. 24, T. 2 S., R. 10 W., 3rd P.M., Monroe County; Waterloo 7.5-minute Quadrangle.**

The Waterloo oil field was discovered in the fall of 1920 when a well was drilled by the Waterloo Condensed Milk Company in T. 2 S., R. 10 W. Pertinent data about this well, including its exact location, either were never obtained or else were lost. A summary of known data concerning this field shows an areal extent of 230 acres in T. 1 S. - T. 2 S., R. 10 W. Oil was produced from about 40 wells that were drilled to an average depth of 410 feet into the Ordovician Kimmswick Limestone Subgroup ("Trenton" in oil field parlance). The Kimmswick Limestone was bowed up along the crest of the Waterloo-Dupo Anticline to form a structural trap in which oil could accumulate. The structure has a closure of about 100 feet, which is the vertical distance between the structure's highest point and its lowest enclosing contour. The average pay zone thickness is about 50 feet. The Waterloo pool was abandoned in 1930 and then revived in 1938. About 269,100 barrels of oil have been produced from this field through 1979. Figure 5 shows a common type of oil production unit in Illinois.

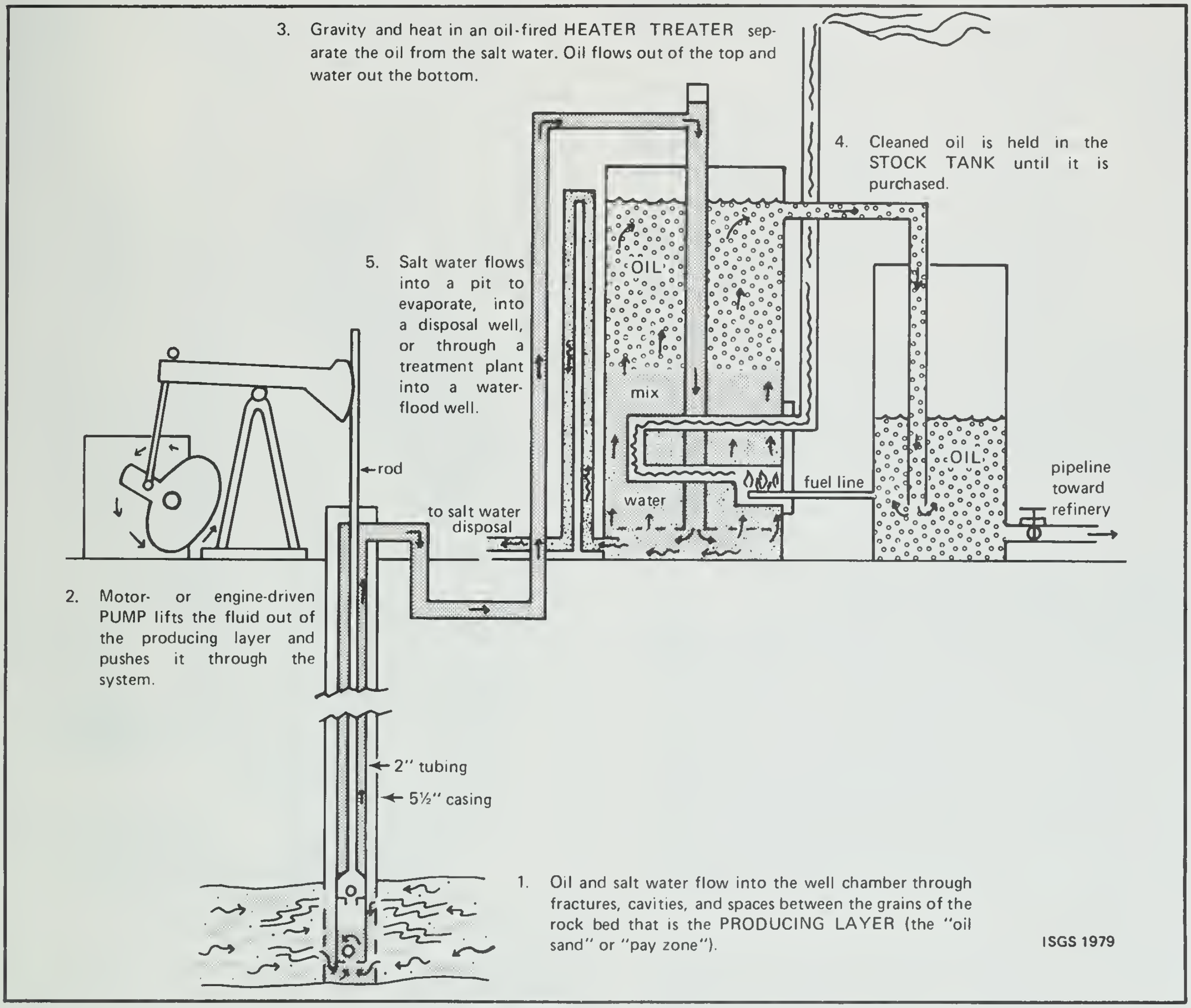


Figure 5. Schematic diagram of a common type of oil production unit in Illinois.

The highest structural point of the Waterloo pool is located about 3.5 miles north-northwest of here in Sec. 34, T. 1 S., R. 10 W. That locality was the site of the Mississippi River Transmission Corporation underground gas storage pumping station. Natural gas was pumped from their main pipeline about one mile to the west of the station and then distributed to a number of injection-withdrawal wells located to the east and southeast along the Waterloo-Dupo Anticline. Although experiments with gas storage in Illinois were made at New Harmony by Superior Oil Company in 1941, the first practical attempt was made by the Mississippi River Transmission Corporation in the Waterloo oil field in 1950.

Natural gas was stored in older Ordovician formations below the Kimmswick: the Oneota Dolomite, New Richmond Sandstone, and St. Peter Sandstone Formations. These strata occur 900 to 1,650 feet below the surface. The top of the Oneota Dolomite has a closure of about 100 feet and the storage area covers approximately 100 acres. Because its area was relatively small, the reservoir served mainly as a surge tank facility to compensate for diurnal demand variations on the line that supplies the St. Louis area. This gas storage project was abandoned in 1973 because of leakage of gas from the structure.

2 **Stop 2. Discussion of the land surveys in Illinois and physiography of the field trip area. Land grant tract; or $^{7}48^{060m}$ E., $^{42}48^{990m}$ N. Universal Transverse Mercator UTM grid, zone 15; or by projection of the township grid, SW¼NE¼SW¼SW¼ Sec. 13, T. 2 S., R. 10 W., 3rd P.M., Monroe County; Waterloo 7.5-minute Quadrangle.**

This locality affords the opportunity of examining the system of land surveys in Illinois. An examination of the 15- and 7.5-minute quadrangles of this part of Illinois shows that section, township, and range lines do not show an even grid pattern over the whole area. In some areas lines shown are quite irregular and represent old French land grants, many of which were established when early French settlers were mainly concerned about the amount of riverfront footage that they could buy.

The location of this stop can be described in several ways as noted in the heading information above. It can be described in relation to the old French land grant lines and corners, for example, 1,470 feet S. 51°30′ W. from the northeast property corner and 1,350 feet N. 56° W. from the southeast property corner (see Map 1). A second way is by using metric measurements based on the Universal Transverse Mercator grid system as was done in the heading. A third way, the use of the township grid system also is illustrated by the heading. Are there other ways that this location could be described?

In 1804, initial surveying from the 2nd P.M. (fig. 6) was carried west of Vincennes, Indiana. This survey became the basis for surveying about 10 percent of what is now eastern Illinois. Because the western boundary of this tract had not been established with certainty, it was decided in 1805 to designate the 3rd P.M. as beginning at the mouth of the Ohio River and extending northward, to facilitate surveying new land cessions. By late 1805 a base line had been run due east to the Wabash River and due west to the Mississippi River from 3rd P.M. During March 1806, surveying commenced northward on both sides of the 3rd P.M. Sometime after the selection of an initial point from which to establish a base line and from which the surveys were to be laid out, the base line apparently was arbitrarily moved north 36 miles, where it roughly coincides with the base line of the 2nd P.M.

The township and range system permits the accurate identification of most parcels of land in Illinois to facilitate the sale and transfer of public and private lands. In the early 1800s, each normal township was divided to the best of the surveyor's ability into 36 sections, each of which was 1 mile square and contained 640 acres (see route map).

Township and range lines in figure 7 do not form a perfect rectangular grid over the state because of the use of different base lines and principal meridians and because minor

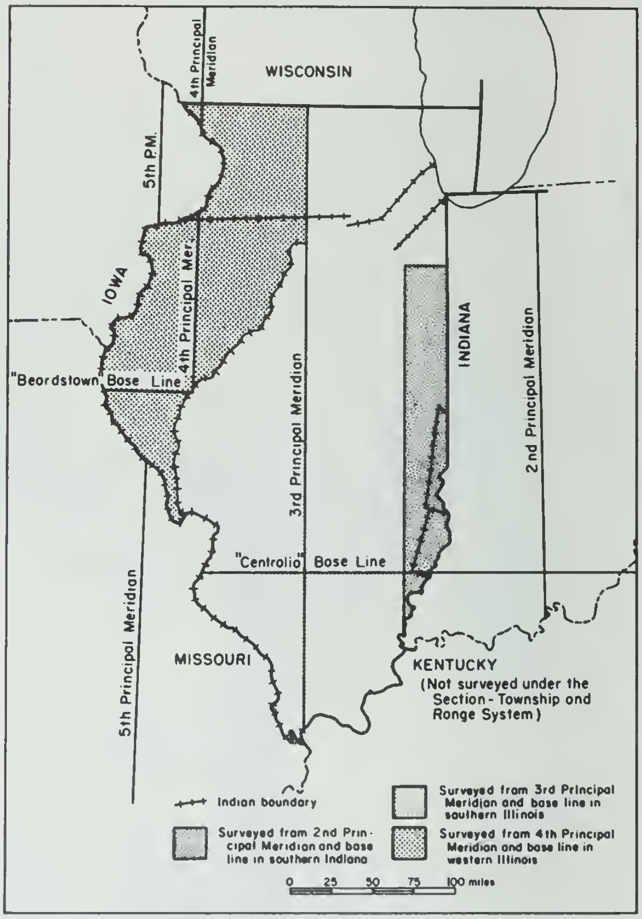


Figure 6. Principal meridians and base lines of Illinois and surrounding states. (From ISGS "Guide to the Use of Illinois Topographic Maps," 1978.)

offsets were necessary to compensate for the Earth's curvature. The surveying corrections producing the minor offsets were usually made at regular intervals of about 30 miles. Figure 7 shows what happened when the survey from the 2nd P.M. met the survey from the 3rd P.M. From Iroquois County south to White County, only narrow partial townships could be made where the two surveys met. These partial townships are all located in R. 11 E. and, in most places, are less than one section wide.

This high vantage point is located close to the crest of the Waterloo-Dupo Anticline; the surface elevation of 685 feet above mean sea level (msl) is closely controlled by the bedrock structure. This high northward-trending ridge is underlain by middle Valmeyeran (Mississippian) limestone (fig. 2).

This area is situated physiographically in the Salem Plateau Section of the Ozark Plateau Province (see attached map "Physiographic Divisions of Illinois"). Late in Tertiary time the Mississippi Valley region was reduced by erosion to a surface of low undulating relief that sloped gently southward. This old erosion surface, the Ozark Peneplain, is preserved in the accordant summit heights visible at the horizon on both sides of the Mississippi River. These summit levels coincide with summit levels on the Buzzard's Point Plain to the southeast in the Shawnee Hills Section in extreme southeastern Illinois, the Calhoun Peneplain to the north in the Lincoln Hills Section, and the Lancaster Peneplain in the Wisconsin Driftless Section of the Upper Mississippi Valley region.

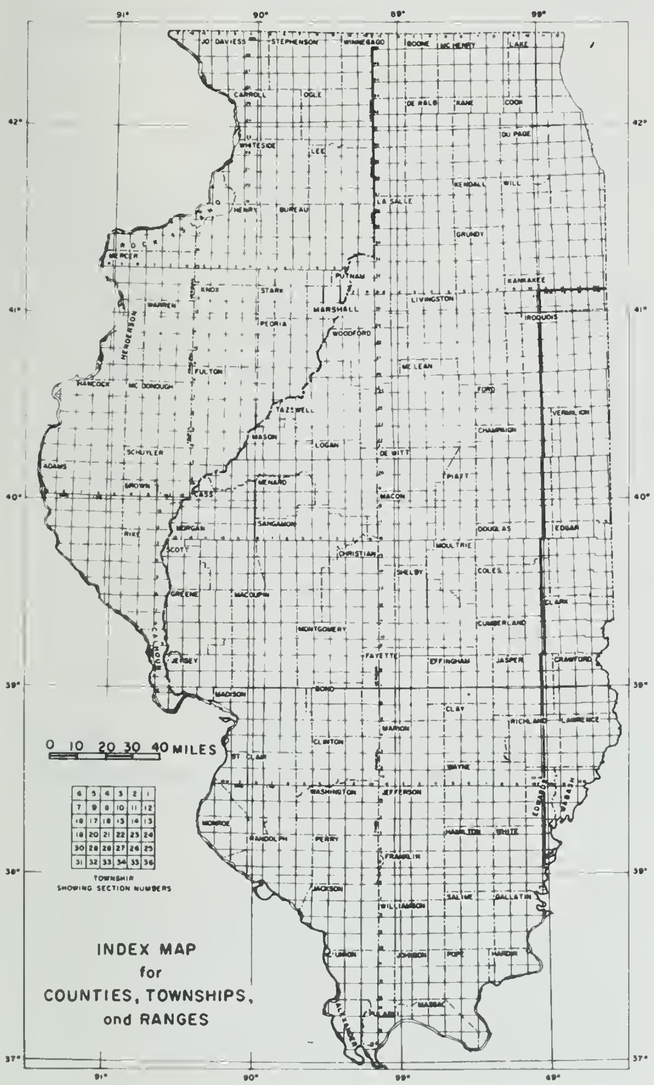


Figure 7. Index map. (From ISGS "Guide to the Use of Illinois Topographic Maps," 1978.)

Late in Tertiary time, during the Pliocene Epoch, uplift of the Ozark Dome changed the direction of slope on the Ozark Peneplain. The peneplain in this region became slightly tilted to the east, northeast, and north around the uplift. Major drainage flowed northward. Early in Pleistocene time (about 1.5 million years ago), with the advance of the Nebraskan glacier from the northwest, northward-flowing streams were dammed by the ice and diverted eastward and southward around the margins of the Ozark Dome. The course of the Mississippi River probably originated at this time as meltwaters sought a southward escape route. Entrenchment of the valley occurred during the post-Nebraskan Aftonian Stage, and during the early part of the Kansan glaciation. Maximum relief in this region was developed during the early part of Kansan time when meltwaters eroded the valley to its greatest depth. Widening, filling, and re-excavating of the valley have taken place during and since the Illinoian and Wisconsinan glaciations.

The upland surface here and to the east was much more rugged before Illinoian glaciation mantled and subdued it with thin deposits of drift. The thick Wisconsinan loess deposits have further subdued the bedrock topography. The Mississippi Valley is incised into the gently eastward-sloping Ozark Peneplain. Summit elevations range from 800 feet west of the river down to 700 feet or slightly less east of the river.

3 **Stop 3. Pleistocene drift exposure. SE¼NE¼ SE¼SW¼ Sec. 9, T. 2 S., R 10 W., 3rd P.M., Monroe County; Waterloo 7.5-minute Quadrangle.**

The succession exposed here from the top downward is as follows:

Quaternary System	
Pleistocene Series	
Wisconsinan Stage	
Altonian Substage	
Roxana Silt — silt, tan-brown with a slight pinkish cast, friable, noncalcareous; surface soil developed in top; B horizon.	3 ft +
Colluvium — quite silty containing a few scattered pebbles and a large angular limestone block about 1 ft across near the top; light brown with slight reddish cast; contains manganese blebs.	3 ft
Sangamonian Stage	
Illinoian Stage	
Liman Substage	
Glasford Formation	
Kellerville Till Member — till, brownish gray at top; Sangamon Soil developed in top; becomes more gray downward; fairly hard near bottom; contains a gravel lens up to 5 in. thick at the bottom; gravel mostly chert fragments, some up to 4 in. across.	2 ft 6 in.
Till, purplish gray-brown, medium hard, sandy; contains manganese blebs; becomes harder and more clayey downward; noncalcareous; oxidized beneath gravel lens.	2 ft 6 in.
Gravel — largely chert with some pieces up to 7 in. across; some igneous pebbles up to 1 in. across; highly oxidized; fairly uniform across exposure.	2 ft ±
Till, yellow-brown and gray, hard, compact; appears to thicken to south across exposure; contains an 18 in. silt zone near the bottom to the south.	1-6 ft
Till, brown with reddish cast, hard, more blocky and silty than till above; thins to south.	1-2.5 ft
Till, grayish brown with pinkish cast, blocky, massive; contains scattered pebbles; looks like loess at first because it maintains such a vertical face.	8 ft ±
Till, similar to above but has more pronounced pinkish cast and is harder and more compact; contains numerous manganese blebs up to ¾ in. diameter by 1 in. long that stick up above the surface; the pitted surface of this till is probably where some of these manganese blebs have been washed out; base concealed.	2.5 ft +
Mississippian System	
Valmeyeran Series	
Ste. Genevieve Limestone — limestone, light gray, oolitic; beds up to 15 in. thick; top concealed	4 ft +
Limestone, very light gray to white, oolitic, thin-bedded; beds up to ½ in. thick; has irregular contact with unit above; base concealed.	9 ft +

The glacial drift in this cut appears to be emplaced in a preglacial valley eroded into the Mississippian bedrock of the area. This brings up some interesting ideas. Because the drift is so far down into Andys Run, there is a distinct possibility that it might be Kansan rather than Illinoian. This locality is almost 2 miles behind the Illinoian glacial margin where the ice may not have had enough erosive power to clean out older drift from some of the deeper valleys. X-ray analysis so far has been inconclusive in identifying the drift. Detailed analyses probably will enable a more positive determination in the near future.

4

Stop 4. Valmeyer Anticline. From SW¼NW¼ NW¼ Sec. 3, T. 3 S., R. 11 W., 3rd P.M., Monroe County; Valmeyer 7.5-minute Quadrangle.

This stop affords an excellent view to the southeast of the Valmeyer Anticline which was named by Stuart and J. Marvin Weller in 1939. From here this structure plunges gently southeastward to the vicinity of Maeystown, a distance of about 10 miles, where it flattens out and disappears (fig. 2). The Valmeyer Anticline, like the Waterloo-Dupo Anticline, is asymmetrical, having a steeper

southwest flank where the strata dip as much as 30 degrees. The northeast flank, on the other hand, has a gentle dip of 1 to 2 degrees. From this vantage point, the dip on both flanks is readily apparent (fig. 8).

The Valmeyer Anticline, an upfold of originally horizontal rock strata, has brought Ordovician bedrock to the surface in the Mississippi River bluffs southeast of this vantage point. The Ordovician Kimmswick Limestone Group is being quarried underground by conventional room and pillar mining methods. This type of mining has produced the many cavernous openings part way up the bluff face.

5 **Stop 5. Valmeyer Quarry. Office: near center NW¼SW¼ Sec. 3, T. 3 S., R. 11 W., 3rd P.M., Monroe County; Valmeyer 7.5-minute Quadrangle.**

This stone operation originally was an open-face quarry in the early 1900s when the MoPac Railroad used the stone for roadbed ballast. Conventional room and pillar underground mining has been carried on for many years in the upper part of the Kimmswick, which is about 100 feet thick here. This limestone is very light gray to white, coarsely crystalline, and quite fossiliferous in some zones. The distinctive fossil *Receptaculites oweni,* the "sunflower coral," occurs in the upper part of the limestone.

Initially the rooms are mined to a height of 22 feet, leaving about 12 feet of the topmost part of the Kimmswick for roof support because the overlying Maquoketa Shale Group is not competent enough for a strong roof. Later mining may deepen the rooms another 18 feet so that in part of the underground works, the ceiling is 38 to 40 feet high. Chert in the lower part of the Kimmswick makes that part of the limestone undesirable and thus limits the depth to which the stone will be mined here. Rooms are 52 feet wide and honeycomb the adjacent hills. Some of the newly quarried stone is trucked underground for 1 to 1.25 miles from the mine face to the processing plant.

The Kimmswick Limestone, which is quite pure, is used in the chemical industry, agricultural feeding material and lime, and for shingle chips. The fine dust from the air-cleaning bagging operation is used for top dressing in blacktop aggregates and as a noncombustible rock dust to apply to walls and ceilings in underground coal mines to help prevent coal dust explosions.

In 1948 the Knaust Mushroom Company leased some of the caverns and began raising mushrooms here in 1951. This firm had a number of mushroom-raising operations and at one time was the largest mushroom grower in the world. Temperature and humidity were relatively easy to maintain in the caverns for optimum growth of the mushrooms and 110 acres of caverns were used for this purpose. Castle and Cooke, Incorporated, purchased the operation in late 1974 and grew mushrooms here until November 1979. The operation was phased out by September 30, 1981. During one growing period, about 2 million pounds of mushrooms were grown at this plant.

Other parts of the mined-out areas have been used for warehousing and the mine was designated the largest Civil Defense Shelter in Illinois. The varied uses of this property demonstrate an excellent example of multiple land use. Easy access to the MoPac Railroad main line in conjunction with the forthcoming completion of the interstate highway loop around the southern end of the St. Louis Metro Area may encourage renewed interest in this property for storage and manufacturing purposes, because zoning ordinances are becoming more restrictive regarding the indiscriminate sprawl of manufacturing and storage facilities across prime farm land.

6 **Stop 6. Valmeyer town park. LUNCH. By projection of the township grid, S½SE¼SW¼ SW¼ Sec. 3, T. 3 S., R. 11 W., 3rd P.M., Monroe County; Valmeyer 7.5-minute Quadrangle.**

7 **Stop 7. Exposed geologic section. NE¼NW¼SE¼ Sec. 2, T. 3 S., R. 11 W., 3rd P.M., Monroe County; Valmeyer 7.5-minute Quadrangle.**

This exposure along the eastern part of Dennis Hollow is one of several noted since leaving Valmeyer that show this hollow to contain one of the best exposed geologic sections in the State. The following section that is exposed here was described by L. E. Workman in a 1949 Association of American Petroleum Geologists' guidebook:

Mississippian System	
Warsaw Formation	
5. Shale, calcareous, yellowish to grey; limestone lenses; fossiliferous (sic)	13 ft
Keokuk Formation	
4. Limestone, shaly, cherty, glauconitic, light greenish gray	16 ft
3. Limestone, cherty, gray, crinoidal	3 ft
2. Shale	2 ft
Burlington Formation	
1. Limestone, cherty, light gray, coarse	3 ft
Total	37 ft

8 **Stop 8. Mammoth Cave of Illinois. Entrance to cave in NW¼SW¼NW¼NE¼ Sec. 31, T. 3 S., R. 9 W., 3rd P.M., Monroe County; Renault 7.5-minute Quadrangle.**

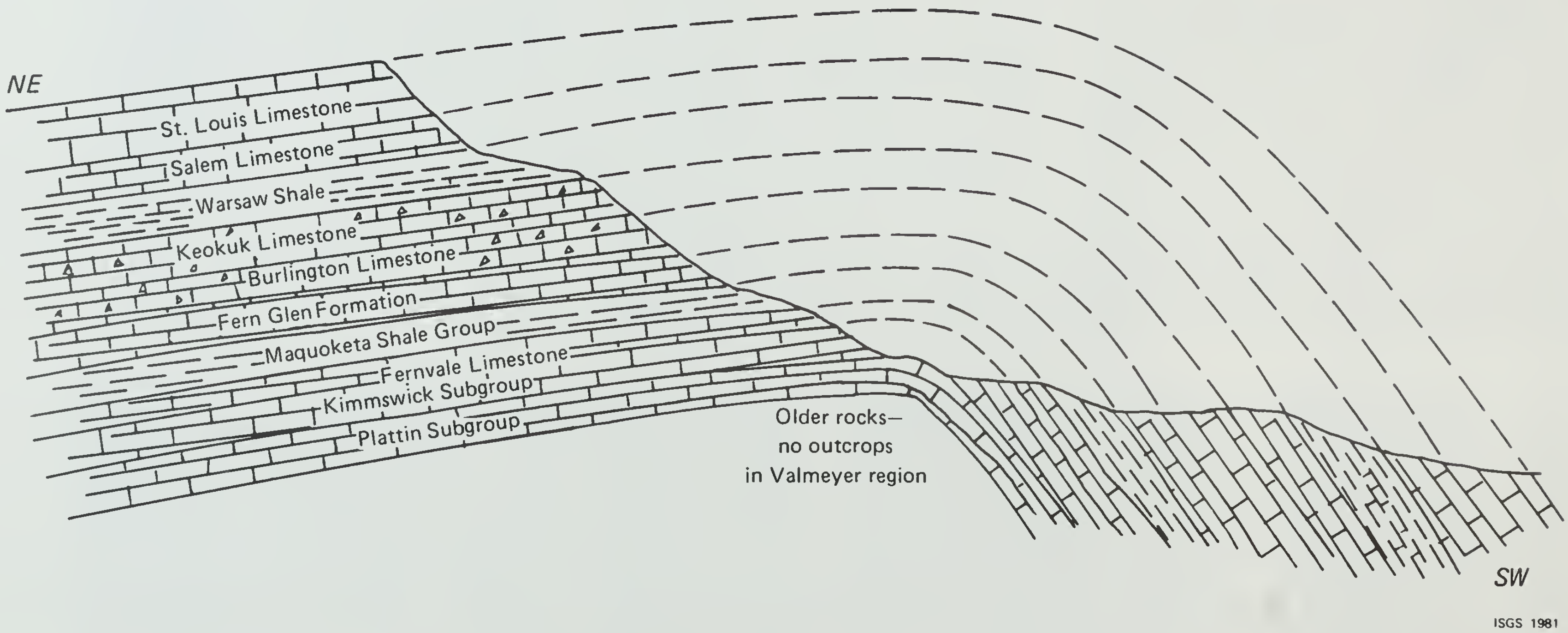


Figure 8. Cross section through Valmeyer Anticline showing the formations that outcrop in the Valmeyer region. Note how the resistant limestones form steep bluffs whereas the weak shales of the Maquoketa and Warsaw become slopes. The dashed lines show how the fold looked before erosion.

Mammoth Cave of Illinois has been known since at least the early 1800s but few people had ventured into it until the latter part of that century and the early 1900s. The cave was operated as a commercial venture from 1901 to 1906. A concrete stairway was constructed along with walkways, bridges, and retaining walls that were necessary for reasonably safe passage throughout at least part of the cave. Early accounts of the cave gave exaggerated estimates of its length, as much as 14 miles long. More recent work using better measuring devices shows the cave to be about 5 miles long, still a large cave for Illinois.

Mammoth Cave of Illinois has also been called Burksville Cave and Illinois Caverns. Bretz and Harris (1961), who made a preliminary study of the cave but no map, preferred the latter name, feeling that it was more apropos.

This part of Illinois is the most densely pocked with sinkholes, which developed in the outcrop belt of the Mississippian St. Louis Limestone Formation to form a highly pitted to undulating hummocky topography. Most of the sinkholes in this area have gently sloped sides and are called "dolines." Although most are without apparent bottom outlets, a few sinkholes do have steep sides, are relatively deep, and have rock-rimmed holes leading down into caves.

Terrain characterized by subsurface drainage, caves, sinkholes, and related solutional features is called "karst topography." There are four conditions that contribute to the development of karst topography. First, there must be at or near the surface a soluble rock, preferably limestone, and the limestone should be essentially horizontal. Second, and one of the most important factors, the limestone should be dense, highly jointed, and preferably thinly bedded. If the limestone is porous, rainwater will be absorbed and move through the whole body of the rock rather than be concentrated along joints and bedding planes. Third, below the upland, major valleys must be entrenched to act as outlets toward which groundwater can move in the subsurface. Fourth, there must be ample rainfall.

Although these conditions are fulfilled to varying degrees in the field trip area, many of the other surface and subsurface solution features associated with karst topography are either not developed here or are not known to exist here. Therefore, the term "karst topography" should not be applied to this area; "sinkhole topography" would be more appropriate.

Sinkholes form in two ways—by roof collapse of caves near the surface and by solutional enlargement of fissures from the surface downward. In the first way, sinkhole formation takes place following uplift and entrenchment of major drainage after an initial period of cavern development by vadose water (percolating groundwater above the zone of saturation, i.e., above the water table). Collapse sinks, known as ponors, are usually deep and steep-walled. In the second way, large subterranean cavities may not even exist. These sinkholes, called dolines, may form at any time in the karst cycle. Dolines are usually shallow, saucer-shaped depressions whose depth is controlled by the depth of the water table at the time of formation. Both types of sinks are usually present in a sinkhole area. Some of the larger sinkholes in this area are probably collapse sinks, but most are dolines.

Cavern formation in Illinois occurred mainly under vadose conditions late in the Pliocene Epoch, more than 1.5 million years ago, and early in the Pleistocene Epoch before entrenchment of the Mississippi River valley. During this time dolines were forming by phreatic solution (solution by water under hydrostatic pressure in the zone of saturation, i.e., below the water table) under high water table conditons. Since entrenchment of the Mississippi River valley, the caves and sinkholes have been slowly enlarged by vadose water. Some collapse sinks have formed. The deposition of glacial drift over the upland in the field trip area has slowed the process, but vadose solution has continued throughout Pleistocene time and up to the present. Many sinkholes are filled or buried by till and loess.

Depressions of several feet may suddenly develop anywhere in a field when the bottoms of these plugged sinkholes open up. No doubt cultivation has been the cause of some of this. As you have noted during the day, the depths of the sinkholes do not determine whether they are filled with water. Dry, deep sinkholes may be adjacent to shallow, water-filled sinkholes. Thus the water level in the sinks is not influenced by the water table. Rather, it is determined by how tightly they are plugged by drift and clay.

If you go into the cave, please do NOT break any cave ornamentation. Leave previously broken cave ornaments (stalactites, stalagmites, etc.) where you find them in the cave so that others may enjoy them. They never look as good at home as they do when they are observed in the cave. The formation of cave deposits is a slow process. Percolating groundwater has dissolved calcium carbonate ($CaCO_3$) from the overlying limestone layers. Partial evaporation causes the dripwater to become saturated with $CaCO_3$ causing the carbonate to be precipitated or left behind as small stalactites or "cave straws." This process repeated over many, many years gradually increases the size of the stalactite. The other process for dripstone deposition takes place through the loss of carbon dioxide (CO_2) from dripwater. The CO_2 is picked up by water from organic materials and air. The CO_2 increases the ability of the water to dissolve $CaCO_3$. Evaporation and/or a temperature change in the percolating dripwater causes it to lose some of the CO_2, thus permitting the deposition of $CaCO_3$ throughout much of the cave.

Please do NOT try to collect the fossils that you will see in the roof of the cave. We hope that you have en-

joyed your trip and haven't scared too many bats on this Halloween! Have a safe journey home and come on the spring field trips to learn about other areas of our State.

BIBLIOGRAPHY

Anonymous, 1901, Mammoth Cave near St. Louis explored by the Post-Dispatch reveals many wonders: St. Louis Post-Dispatch, v. 53, no. 180, Feb. 17, p. 1 and 4.

Anonymous, 1920, Geology and oil and gas possibilities in the vicinity of Waterloo, Monroe County, Illinois: Illinois State Geological Survey, Press Bulletin 3, 4 p.

Baxter, J. W., 1960, Salem Limestone in southwestern Illinois: Illinois State Geological Survey, Circular 284, 32 p.

Bell, A. H., 1929, The Dupo oil field: Illinois State Geological Survey, Illinois Petroleum 17, 20 p.

Bretz, J H, and S. E. Harris, Jr., 1961, Caves of Illinois: Illinois State Geological Survey, Report of Investigations 215, 87 p.

Bristol, H. M., and T. C. Buschbach, 1973, Ordovician, Galena Group (Trenton) of Illinois—structure and oil fields: Illinois State Geological Survey, Illinois Petroleum 99, 38 p.

Buschbach, T. C., and D. C. Bond, 1974, Underground storage of natural gas in Illinois—1973: Illinois State Geological Survey, Illinois Petroleum 101, 71 p.

Collinson, C. W., et al., 1981, Mississippian stratotypes: Illinois State Geological Survey, Field Guidebook *and* 15th Annual Meeting of the North-Central Section, Geological Society of America, 61 p.

Cote, W. E., et al., 1970, Millstadt-Dupo area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1970 A & F, 39 p.

Cote, W. E., 1972, Guide to the preparation and use of Illinois topographic maps: Illinois State Geological Survey, Educational Extension Publication, (Rev. 1978), 26 p.

Killey, M. M., 1975, Erratics are erratic: Illinois State Geological Survey, Geogram 2, 2 p.

Killey, M. M., 1975, Ancient dust storms in Illinois: Illinois State Geological Survey, Geogram 5, 2 p.

Lamar, J. E., 1922, Notes on the Waterloo Anticline: Illinois State Geological Survey, Press Bulletin 11, 8 p.

Mylius, L. A., 1920, Oil and gas prospecting outside southeastern Illinois: Illinois State Geological Survey, Press Bulletin 6, 1 p.

Mylius, L. A., 1921, Oil and gas in Monroe County, Illinois: Illinois State Geological Survey, Press Bulletin 7, 2 p.

Mylius, L. A., 1921, Oil possibilities of the Posten School structure, Monroe County, Illinois: Illinois State Geological Survey, Press Bulletin 9, 4 p.

Odum, I. E., G. M. Wilson, and G. Dow, 1961, Valmeyer area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1961-F, 19 p.

Piskin, K., and R. E. Bergstrom, 1975, Glacial drift in Illinois: thickness and character: Illinois State Geological Survey Circular 490, 35 p.

Raasch, G. O., 1950, Waterloo area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1950-F, 11 p.

Reinertsen, D. L., 1979, A guide to the geology of the Westfield-Casey Area—Clark, Coles, Cumberland Counties, Illinois: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1979-A, 38 p.

Samson, I., Illinois mineral industry in 1979 and review of preliminary mineral production data for 1980: Illinois State Geological Survey Illinois Mineral Note, in preparation.

Selkregg, L. F., W. A. Pryor, and J. P. Kempton, 1957, Groundwater geology in south-central Illinois: Illinois State Geological Survey, Circular 225, 30 p.

Smith, W. H., 1958, Strippable coal reserves of Illinois. Part 2—Jackson, Monroe, Perry, Randolph, and St. Clair Counties: Illinois State Geological Survey, Circular 260, 35 p.

Treworgy, J. D., 1981, Structural features in Illinois—a compendium: Illinois State Geological Survey, Circular 519, 22 p.

Weller, S., and J. M. Weller, 1939, Preliminary geologic maps of the pre-Pennsylvanian formations in part of southwestern Illinois—Waterloo, Kimmswick, New Athens, Crystal City, Renault, Baldwin, Chester, and Campbell Hill Quadrangles: Illinois State Geological Survey, Report of Investigation 59, 15 p.

Willman, H. B., et al., 1967, Geologic map of Illinois: Illinois State Geological Survey Map.

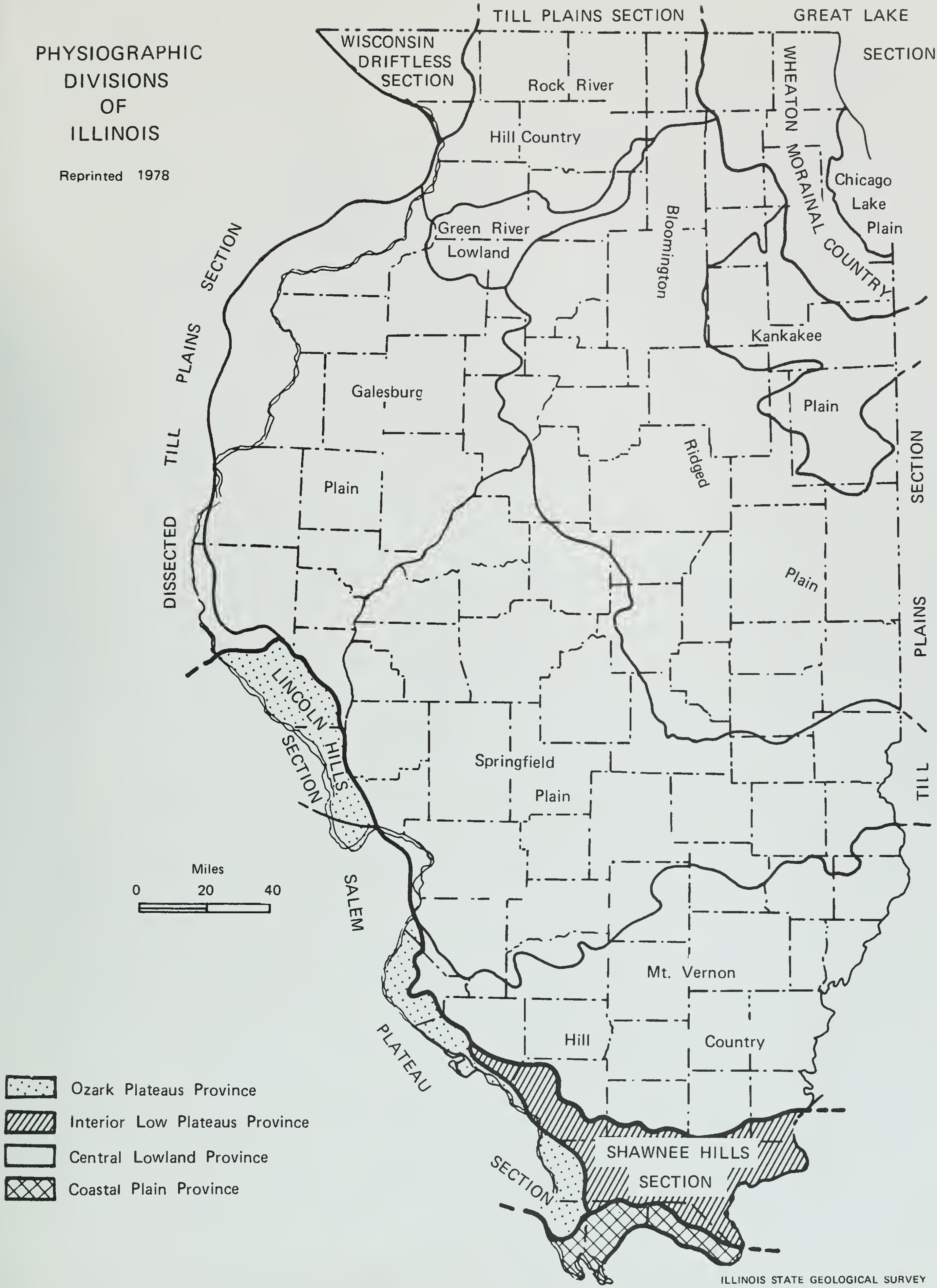
Willman, H. B., et al., 1975, Handbook of Illinois stratigraphy: Illinois State Geological Survey, Bulletin 95, 261 p.

Willman, H. B., and J. C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.

Willman, H. B., L. E. Workman, and A. H. Bell, 1949, Guide to field study in southwestern Illinois between Cape Girardeau and St. Louis, Missouri, *in* Guidebook for 34th annual field conference: American Association of Petroleum Geologists, p. 18-30.

PHYSIOGRAPHIC DIVISIONS OF ILLINOIS

Reprinted 1978



ILLINOIS STATE GEOLOGICAL SURVEY

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, the period of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. Ice sheets formed in sub-arctic regions four different times and spread outward until they covered the northern parts of Europe and North America. In North America the four glaciations, in order of occurrence from the oldest to the youngest, are called the Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed during periods when the mean annual temperature was perhaps 4° to 7° C (7° to 13° F) cooler than it is now and winter snows did not completely melt during the summers. Because the cooler periods lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was probably enough to lower sea level more than 300 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called drift. Drift that is ice-laid is called till. Water-laid drift is called outwash.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also unstratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders.

Tills may be deposited as end moraines, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as ground moraines, or till plains, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called outwash. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size--the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an esker. Cone-shaped mounds of coarse outwash, called kames, were formed where meltwater plunged through crevasses in the ice or into ponds along the edge of the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake quickly lost speed and almost immediately dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were moved across the lake bottom by wind-generated

currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an outwash plain. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as valley trains. Valley trains may be both extensive and thick deposits. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess and Soils

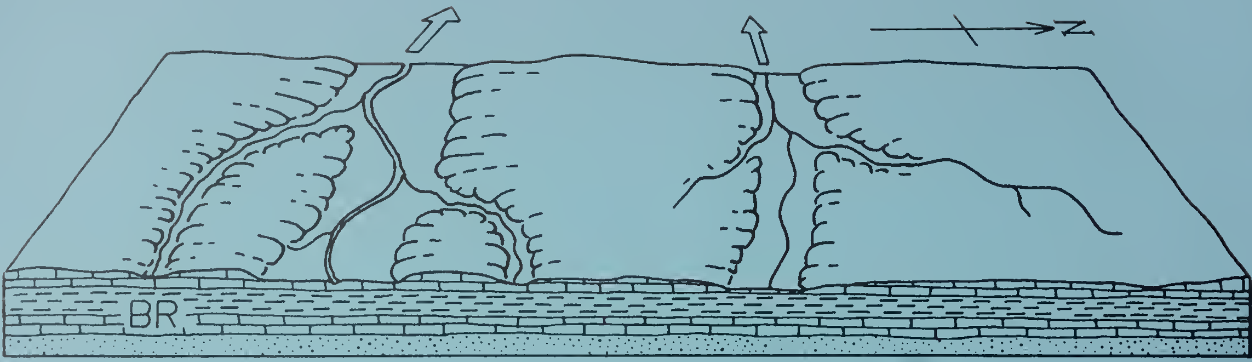
One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. Loess is the name given to such deposits of windblown silt and clay. The silt was blown from the valley trains on the floodplains. Most loess deposition occurred in the fall and winter seasons when low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but those that survive serve as keys to the identity of the beds and are evidence of the passage of a long interval of time.

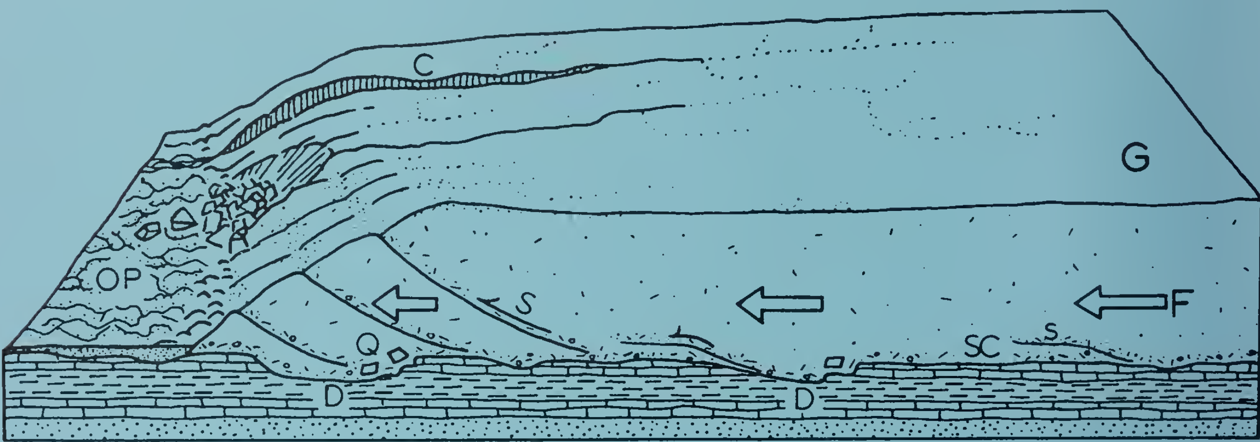
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

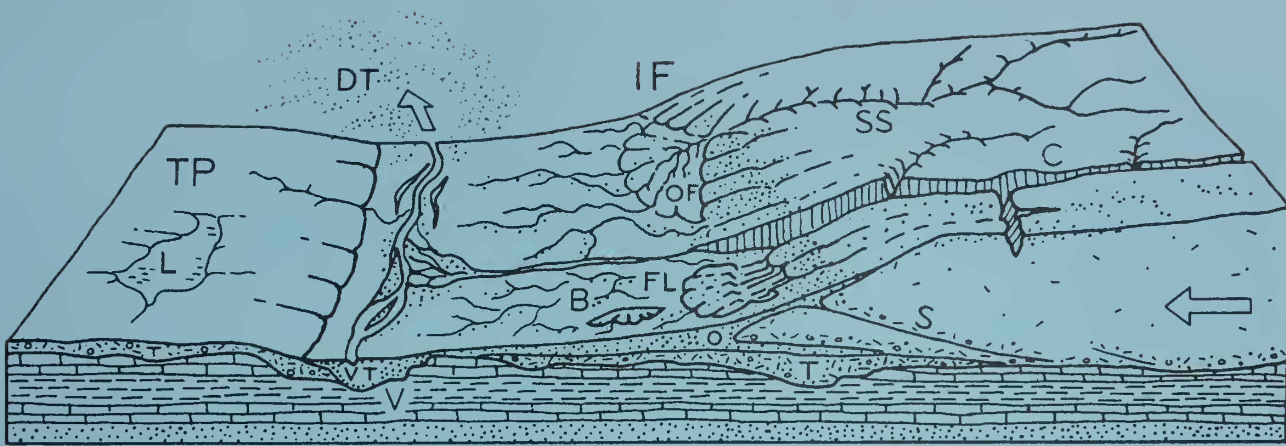
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated--layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. The Region Before Glaciation - Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks--layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



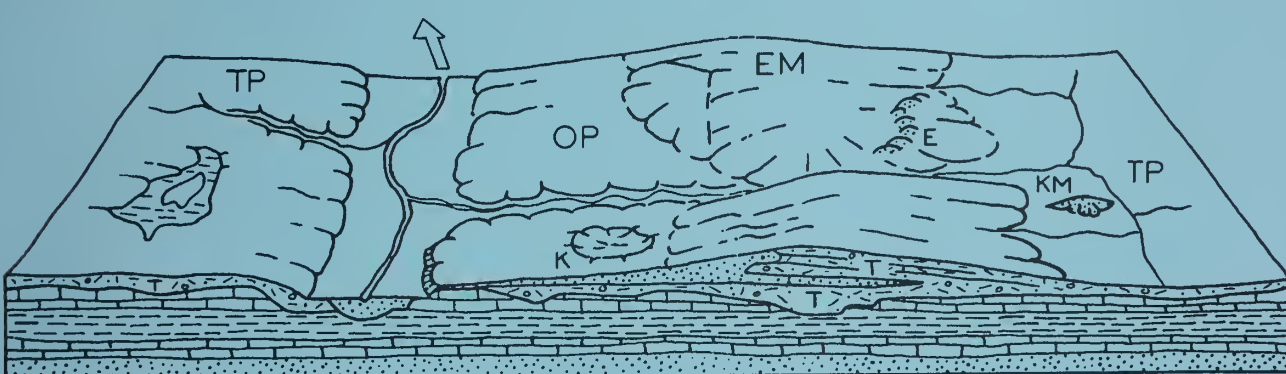
2. The Glacier Advances Southward - As the glacier (G) spreads out from its snowfield, it scours (SC) the soil and rock surface and quarries (Q)--pushes and plucks up--chunks of bedrock. These materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before the ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick , except near its margin. Its ice front advances perhaps as much as a third of a mile per year.



3. The Glacier Deposits an End Moraine - After the glacier advanced across the area, the climate warmed and the ice began to melt as fast as it advanced. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that was mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A superglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) was left as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remained a low spot in the terrain. As soon as its ice cover melted, meltwater drained down the valley, cutting it deeper. Later, outwash partly refilled the valley--the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles.



4. The Region after Glaciation - The climate has warmed even more, the whole ice sheet has melted, and the glaciation has ended. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

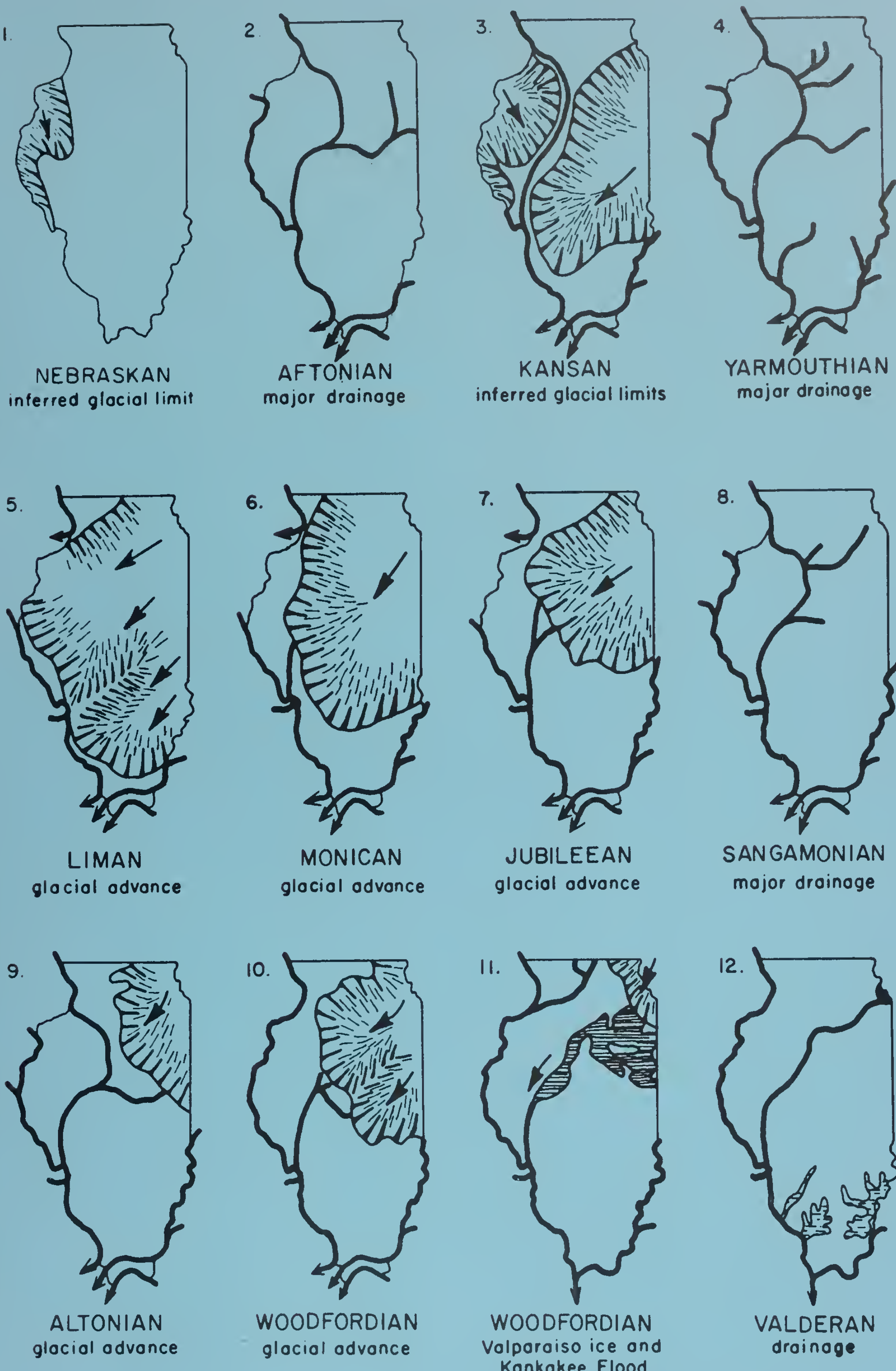
Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

TIME TABLE OF PLEISTOCENE GLACIATION

STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
HOLOCENE	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
	7,000		
WISCONSINAN (4th glacial)	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
	11,000		
	Twocreekan	Peat and alluvium	Ice withdrawal, erosion
	12,500		
	Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
	22,000		
	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
	28,000		
	Altonian	Drift, loess	Glaciation in northern Illinois, valley trains along major rivers
	75,000		
SANGAMONIAN (3rd interglacial)		Soil, mature profile of weathering	
	175,000		
ILLINOIAN (3rd glacial)	Jubileean	Drift, loess	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
	Monican	Drift, loess	
	Liman	Drift, loess	
	300,000		
YARMOUTHIAN (2nd interglacial)		Soil, mature profile of weathering	
	600,000		
KANSAN (2nd glacial)		Drift, loess	Glaciers from northeast and northwest covered much of state
	700,000		
AFTONIAN (1st interglacial)		Soil, mature profile of weathering	
	900,000		
NEBRASKAN (1st glacial)		Drift	Glaciers from northwest invaded western Illinois
	1,200,000 or more		

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(From Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)

ILLINOIS STATE GEOLOGICAL SURVEY

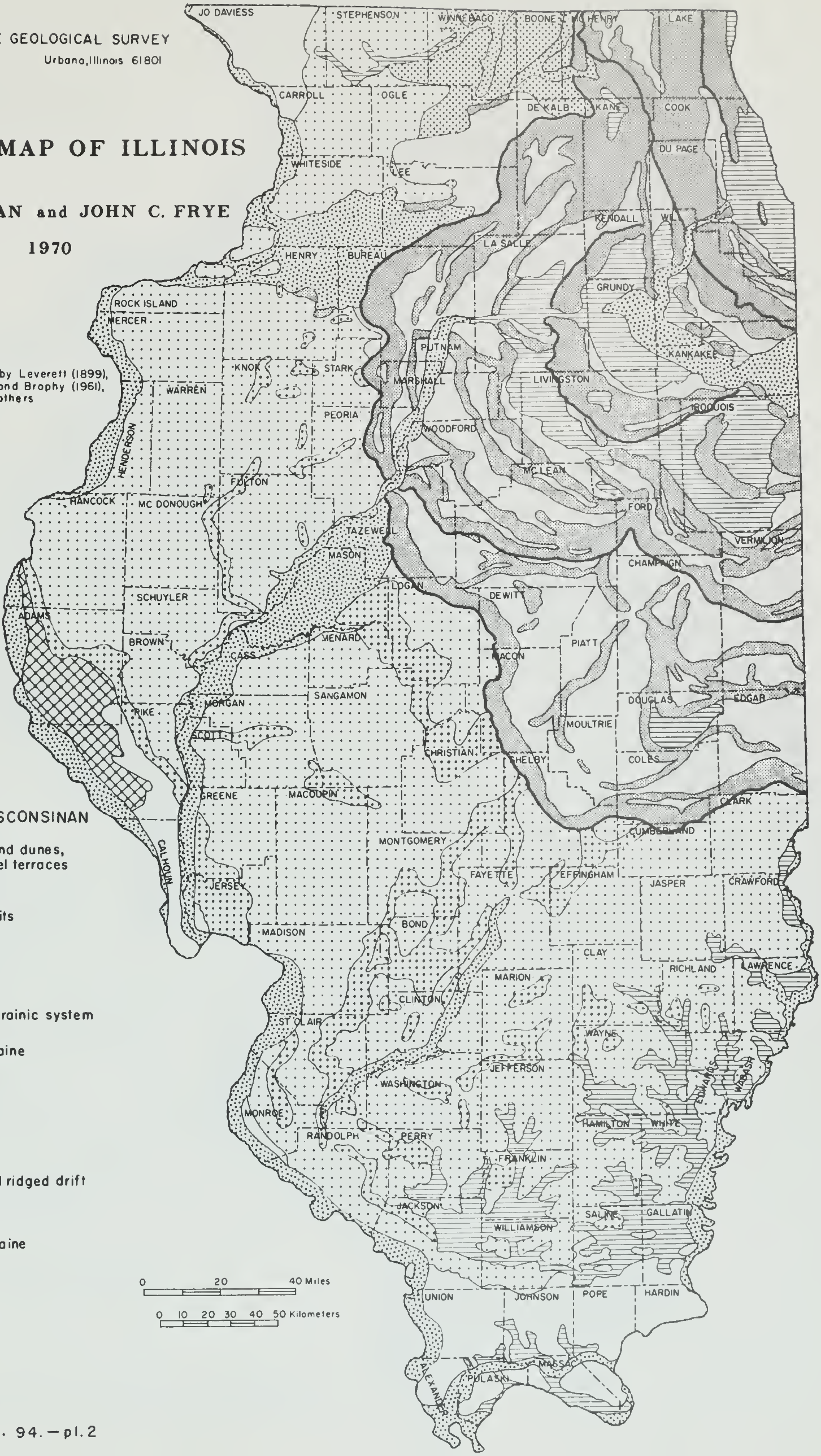
John C. Frye, Chief   Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others



EXPLANATION

HOLOCENE AND WISCONSINAN

Alluvium, sand dunes, and gravel terraces

WISCONSINAN

Lake deposits

WOODFORDIAN

Moraine

Front of morainic system

Groundmoraine

ALTONIAN

Till plain

ILLINOIAN

Moraine and ridged drift

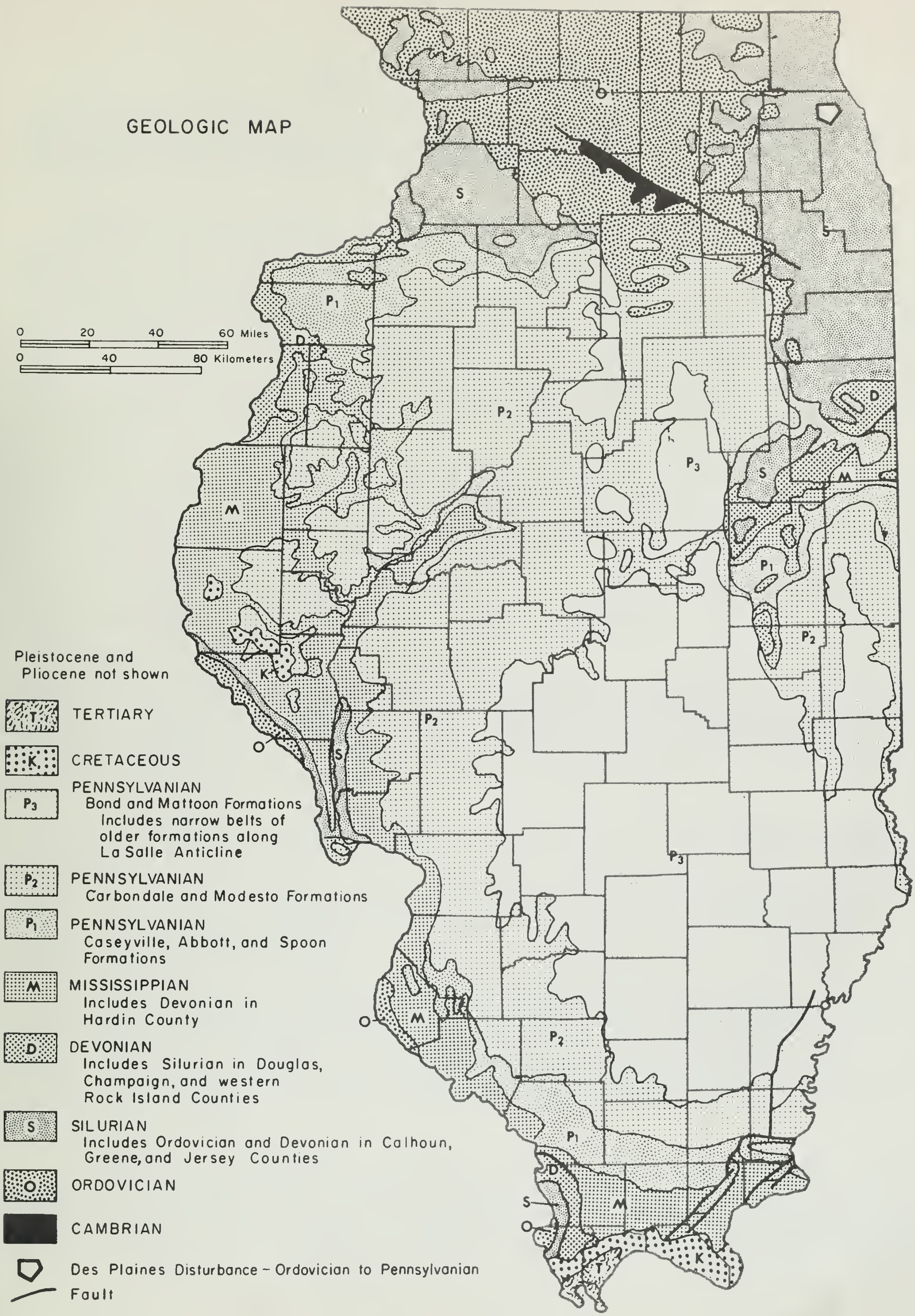
Groundmoraine

KANSAN

Till plain

DRIFTLESS

Modified from Bull. 94.—pl. 2


GEOLOGIC MAP
0 20 40 60 Miles
0 40 80 Kilometers
Pleistocene and Pliocene not shown
TERTIARY
CRETACEOUS
PENNSYLVANIAN
Bond and Mattoon Formations
Includes narrow belts of older formations along La Salle Anticline
PENNSYLVANIAN
Carbondale and Modesto Formations
PENNSYLVANIAN
Caseyville, Abbott, and Spoon Formations
MISSISSIPPIAN
Includes Devonian in Hardin County
DEVONIAN
Includes Silurian in Douglas, Champaign, and western Rock Island Counties
SILURIAN
Includes Ordovician and Devonian in Calhoun, Greene, and Jersey Counties
ORDOVICIAN
CAMBRIAN
Des Plaines Disturbance – Ordovician to Pennsylvanian
Fault

MISSISSIPPIAN DEPOSITION

(The following quotation is from Report of Investigations 216: Classification of Genevievian and Chesterian...Rocks of Illinois [1965] by D. H. Swann, pp. 11-16. One figure and short sections of the text are omitted.)

During the Mississippian Period, the Illinois Basin was a slowly subsiding region with a vague north-south structural axis. It was flanked by structurally neutral regions to the east and west, corresponding to the present Cincinnati and Ozark Arches. These neighboring elements contributed insignificant amounts of sediment to the basin. Instead, the basin was filled by locally precipitated carbonate and by mud and sand eroded from highland areas far to the northeast in the eastern part of the Canadian Shield and perhaps the northeastward extension of the Appalachians. This sediment was brought to the Illinois region by a major river system, which it will be convenient to call the Michigan River (fig. 4) because it crossed the present state of Michigan from north to south or northeast to southwest....

The Michigan River delivered much sediment to the Illinois region during early Mississippian time. However, an advance of the sea midway in the Mississippian Period prevented sand and mud from reaching the area during deposition of the St. Louis Limestone. Genevievian time began with the lowering of sea level and the alternating deposition of shallow-water carbonate and clastic units in a pattern that persisted throughout the rest of the Mississippian. About a fourth of the fill of the basin during the late Mississippian was carbonate, another fourth was sand, and the remainder was mud carried down by the Michigan River.

Thickness, facies, and crossbedding...indicate the existence of a regional slope to the southwest, perpendicular to the prevailing north 65° west trend of the shorelines. The Illinois Basin, although developing structurally during this time, was not an embayment of the interior sea. Indeed, the mouth of the Michigan River generally extended out into the sea as a bird-foot delta, and the shoreline across the basin area may have been convex more often than concave.

....The shoreline was not static. Its position oscillated through a range of perhaps 600 to 1000 or more miles. At times it was so far south that land conditions existed throughout the present area of the Illinois Basin. At other times it was so far north that there is no suggestion of near-shore environment in the sediments still preserved. This migration of the shoreline and of the accompanying sedimentation belts determined the composition and position of Genevievian and Chesterian rock bodies.

Lateral shifts in the course of the Michigan River also influenced the placement of the rock bodies. At times the river brought its load of sediment to the eastern edge of the basin, at times to the center, and at times to the western edge. This lateral shifting occurred within a range of about 200 miles. The Cincinnati and Ozark areas did not themselves provide sediments, but, rather, the Michigan River tended to avoid those relatively positive areas in favor of the down-warped basin axis.

Sedimentation belts during this time were not symmetrical with respect to the mouth of the Michigan River. They were distorted by the position of the river relative to the Ozark and Cincinnati shoal areas, but of greater importance was sea current or drift to the northwest. This carried off most of the mud contributed by the river, narrowing the shale belt east of the river mouth and broadening it west

of the mouth. Facies and isopach maps of individual units show several times as much shale west of the locus of sand deposition as east of it. The facies maps of the entire Chesterian...show maximum sandstone deposition in a northeast-southwest belt that bisects the basin. The total thickness of limestone is greatest along the southern border of the basin and is relatively constant along that entire border. The proportion of limestone, however, is much higher at the eastern end than along the rest of the southern border, because little mud was carried southeastward against the prevailing sea current. Instead, the mud was carried to the northwest and the highest proportion of shale is found in the northwestern part of the basin.

Genevievian and Chesterian seas generally extended from the Illinois Basin eastward across the Cincinnati Shoal area and the Appalachian Basin. Little terrigeneous sediment reached the Cincinnati Shoal area from either the west or the east, and the section consists of thin limestone units representing all or most of the major cycles. The proportion of inorganically precipitated limestone is relatively high and the waters over the shoal area were commonly hypersaline... Erosion of the shoal area at times is indicated by the presence of conodonts eroded from the St. Louis Limestone and redeposited in the lower part of the Gasper Limestone at the southeast corner of the Illinois Basin...

The shoal area included regions somewhat east of the present Cincinnati axis and extended from Ohio, and probably southeastern Indiana, through central and east-central Kentucky and Tennessee into Alabama....

Toward the west, the seaway was commonly continuous between the Illinois Basin and central Iowa, although only the record of Genevievian and earliest Chesterian is still preserved. The seas generally extended from the Illinois and Black Warrior regions into the Arkansas Valley region, and the presence of Chesterian outliers high in the Ozarks indicates that at times the Ozark area was covered. Although the sea was continuous into the Ouachita region, detailed correlation of the Illinois sediments with the geosynclinal deposits of this area is difficult.

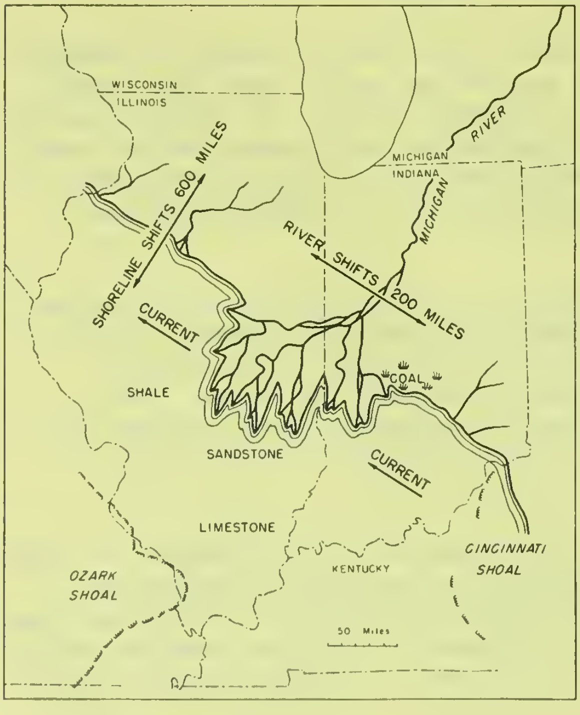
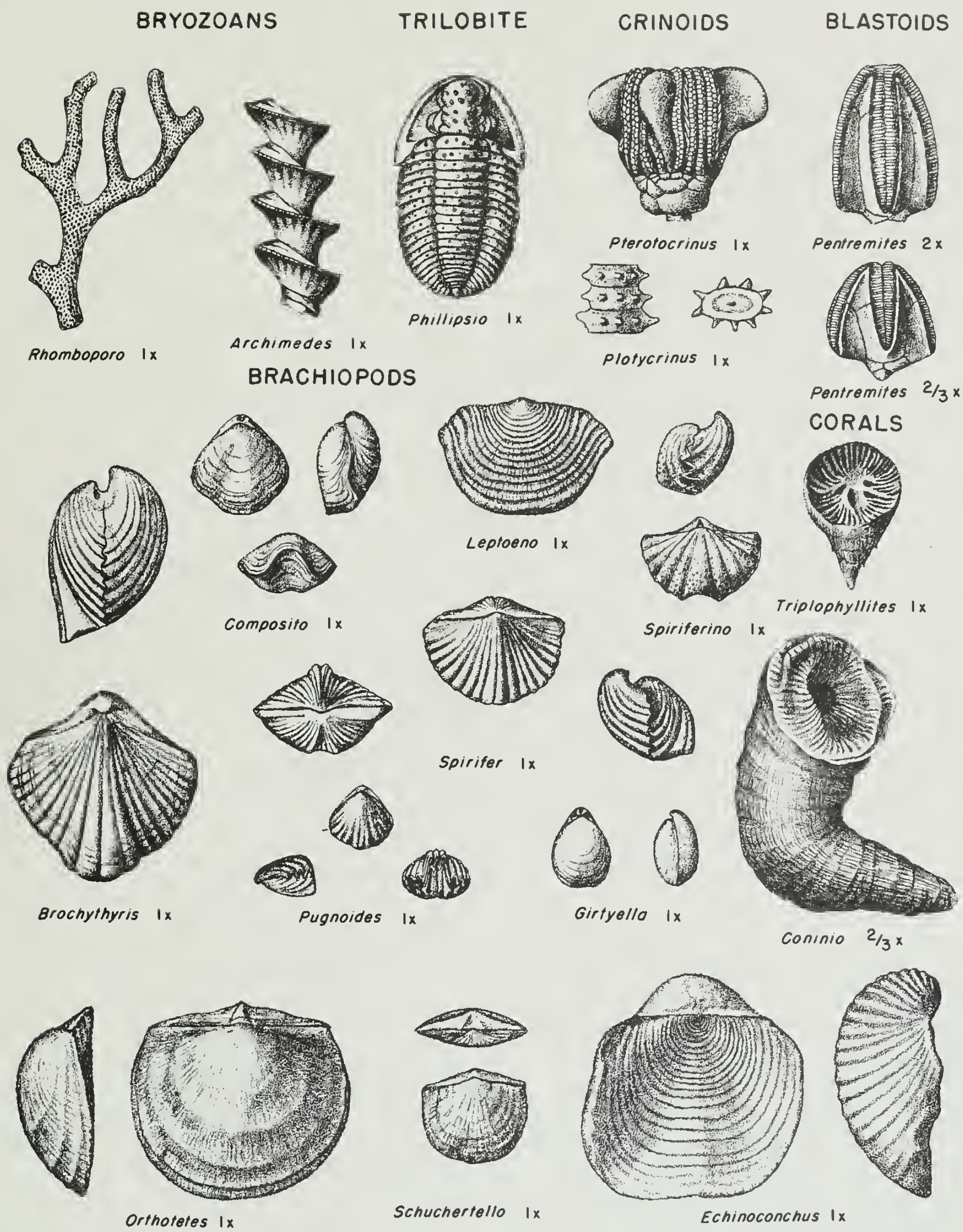
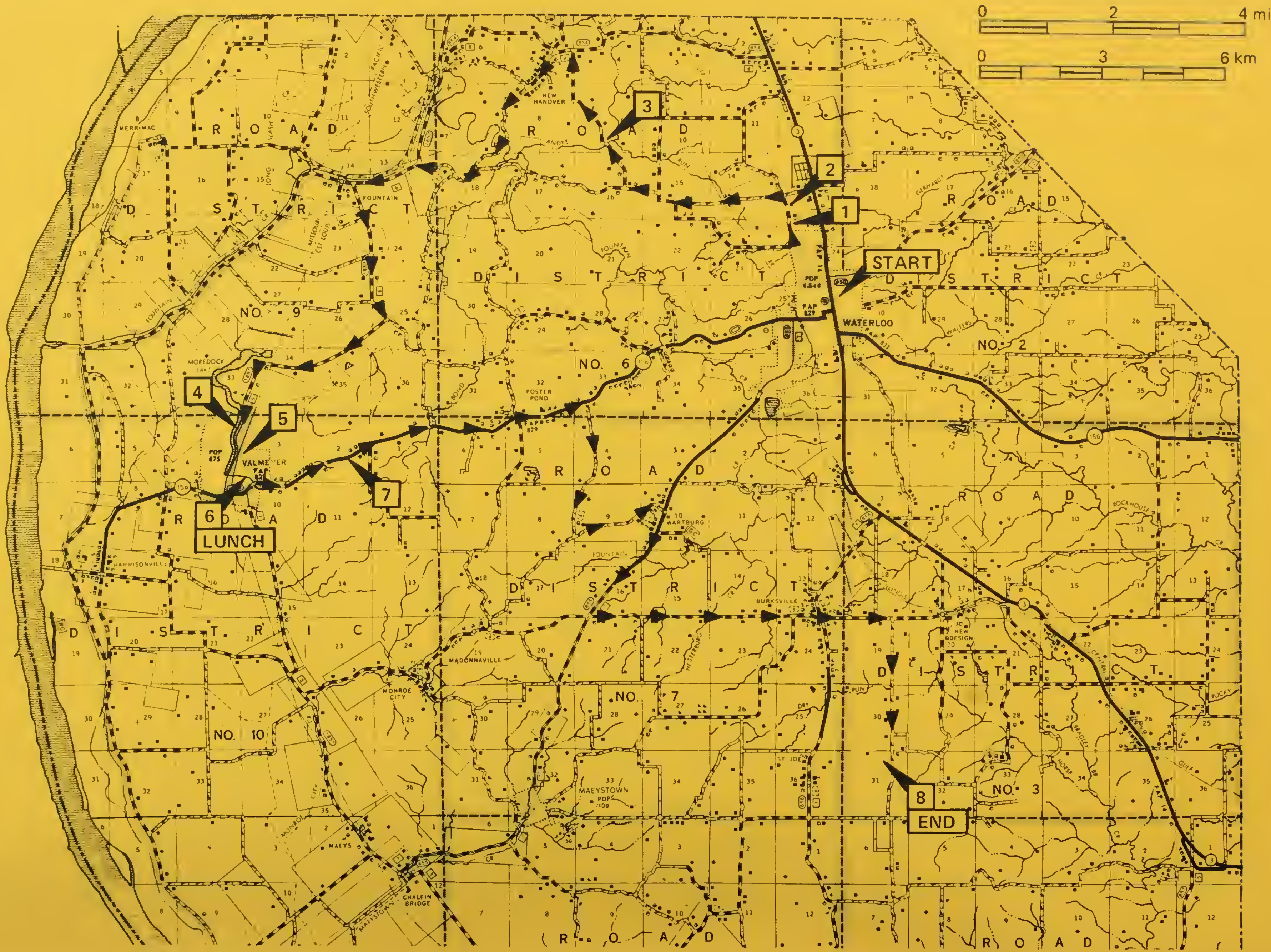


Figure 4: Paleogeography at an intermediate stage during Chesterian sedimentation.


BRYOZOANS
TRILOBITE
CRINOIDS
BLASTOIDS
Rhombopora 1x
Archimedes 1x
Phillipsia 1x
Pterotocrinus 1x
Platycrinus 1x
Pentremites 2x
Pentremites 2/3 x
BRACHIOPODS
CORALS
Leptaena 1x
Composita 1x
Spiriferina 1x
Triplophyllites 1x
Spirifer 1x
Brachythyris 1x
Pugnoides 1x
Girtyella 1x
Caninia 2/3 x
Orthotetes 1x
Schuchertella 1x
Echinoconchus 1x


0 2 4 mi
0 3 6 km
START
1
2
3
4
5
6
LUNCH
7
8
END
WATERLOO
POP 4,846
NEW HANOVER
FOUNTAIN
MERRIMAC
MOREDOCK LAKE
VALMEYER
POP 875
HARRISONVILLE
FOSTER POND
WARTBURG
BURKSVILLE
NEW DESIGN
MADONNAVILLE
MONROE CITY
MAEYSTOWN
POP 109
MAEYS
CHALFIN BRIDGE
ST JOE
ROAD DISTRICT NO. 2
ROAD DISTRICT NO. 3
ROAD DISTRICT NO. 6
ROAD DISTRICT NO. 7
ROAD DISTRICT NO. 9
ROAD DISTRICT NO. 10